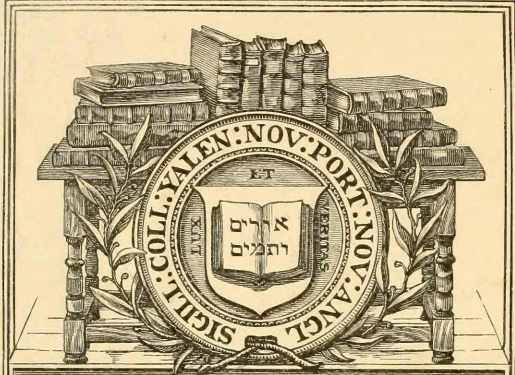
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DISEASES OF THE EYE

A CLINICAL MANUAL OF DISEASES OF THE EYE

INCLUDING A

SKETCH OF ITS ANATOMY

BY

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To

MY COLLEAGUES

IN THE

MANHATTAN EYE AND EAR HOSPITAL,

THIS VOLUME IS

RESPECTFULLY AND AFFECTIONATELY DEDICATED.

PREFACE.

This book has not been written because the author supposed, for an instant, that there were not already in the English tongue many excellent treatises on diseases of the eye. It is presented to the profession because I have not deemed that the debt I owe to it could be even approximately satisfied, nor my own reputation as a teacher, whatever that may be, justly settled, unless I presented in a permanent and accessible form some of the results, with their personal coloring, of my long experience both in hospital and private practice, in ophthalmic disease and therapeutics.

To prepare a cyclopedic text-book of ophthalmology has not been my aim. The reader will not find in these pages a notice of all that has been described or suggested by the numerous writers upon diseases of the eye, but I trust that the book will be found a complete and safe guide to the practitioner. In many of the subdivisions of ophthalmology, it would be almost impossible for any writer to say anything novel or original. The labors of renowned men, some of them happily still living, have settled certain points forever; but there are still departments of ophthalmic science and art, in which many things are under discussion and concerning which widely differing views are held, especially in the United States. For my views on these subjects, which are chiefly to be found in the fourth part of this work, I invite an impartial hearing. Those which are true will form a part of an indestructible structure that is still, as it has been for centuries, in process of erection; those theories which

prove to be false will speedily be rejected, as not fit for the builder's use.

For the preparation of the anatomical sketch of the various parts of the eye, I am indebted to the intelligent and painstaking labor of Dr. A. E. Davis. The original drawings in this part were made under his supervision by Dr. H. S. Potter. I have also received valuable assistance in various parts of the work from my associates in private and hospital practice, Dr. J. B. Emerson and Dr. Frank N. Lewis. The Glossary, which has been considered valuable by those using the Ophthalmic and Otic Memoranda, published by the late Dr. Edward T. Ely and myself, has been enlarged for this work, also by Dr. Davis.

The opticians, Messrs. Georgen and Hahn and Mr. E. B. Meyrowitz, have furnished me with many electrotypes of instruments for examining the eye. The other illustrations of instruments are chiefly from the excellent catalogue of the house of Lüer, in Paris. Two of the chromo-lithographic drawings were made from nature by Miss Elkins.

D. B. St. John Roosa.

New York, September, 1894.

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CHAPTER I.

ANATOMY OF THE APPENDAGES OF THE EYE.

Eyebrows.— Eyelids. — Muscles. — Tarsal Cartilages. — Cilia.—Blood-Vessels.— Lachrymal Apparatus.—Muscles of the Eyeball.

EYEBROWS.

(*Supercilia, above the lashes.*)

THE eyebrows are two thickened ridges of integument arched above the upper border of the orbits. They are connected to the underlying muscles, *corrugator supercilii*, *orbicularis palpebrarum*, and *occipito-frontalis*, by rather short and firm connective-tissue fibres. Short hairs, slanting outward, cover the brows from near the median line to the outer extremity of the superciliary ridge. By the action of the underlying muscles, the brows can be pulled downward and slightly inward, and in this way made to protect the eyes, and to limit in a slight measure, the amount of light entering them.

The *corrugator supercilii* is the chief muscle in moving the eyebrows downward and inward. It arises from the inner extremity of the superciliary ridge on the frontal bone, passes outward and upward, to be inserted into the under surface of the upper portion of the orbicularis palpebrarum, oppósite the middle of the orbital arch. It also sends a few fibres of insertion to the *occipito-frontalis* near this point.

FUNCTION.—The function of this muscle is to pull the eyebrows downward and inward. It is innervated by branches from the facial or seventh nerve and from the first division of the fifth nerve.

EYELIDS.

(*Palpebræ, eyelids.*)

The eyelids, upper and lower, are two movable curtains or folds which cover the entrance to the orbit and protect the eye-

ball. The under or posterior surfaces of the lids are kept in contact with the eyeball, by the action of the muscles and by atmospheric pressure. The upper lid is larger and more movable than the lower one, having a special muscle, *levator palpebræ superioris*, to lift it. The lids have two borders or margins, one attached and one free; two surfaces, anterior and posterior; two extremities, outer and inner. The attached or orbital margin of the lids is convex and very thin, gradually shading off into the tarso-orbital fascia which connects the lids to the margins of the orbit.

The free margins of the lids are about one line in thickness; they have two lips, an inner sharp lip and an outer rounded lip. The outer rounded lip is pierced by two or three rows of hairs, the cilia (*c c*, Fig. 1). Just in front of the inner lip, the mouths of the Meibomian glands open (*m*, Fig. 1). On the inner lip of both upper and lower lids, about 2½ lines from the inner canthus, is a small elevation—*lachrymal papilla.* At the summit of each of these papillæ is a small opening, *punctum lachrymale* (*p*, Fig. 3), which is the beginning of the canaliculus leading into the lachrymal sac.

The anterior or outer surface of the lids is convex and formed of a very thin skin, while the posterior or inner surface is concave and formed of conjunctiva. The outer extremity of the lids is sharp, while the inner extremity is rounded off. The space left between the free margins of the lids when the eyes are open is called the *palpebral fissure.* At the outer extremity of this fissure, the free borders of the lids meet at an acute angle to form the *outer canthus;* at the inner extremity the angle between the free borders is somewhat rounded out—*inner canthus* (κανθος, angle of the eye).

The lids are composed of skin, areolar tissue, muscle, fibrous tissue (so-called cartilages), conjunctiva, glands, nerves, blood-vessels and lymphatics.

The *integument* covering the lid and forming its external layer is very thin and quite lax. This latter feature is owing to its loose connection with the underlying tissue. At the free margin of the lid, however, it is firmly attached and is here continuous with the conjunctiva. A few very fine hairs (*h h*, Fig. 1) which have their roots in areolar tissue beneath, stud this.

The mouths of a few sweat glands also open on its surface. The glands themselves (*s*, Fig. 1) are situated, as were the hair bulbs, in the underlying cellular tissue.

The *areolar tissue* is a very long-fibred connective tissue which joins the integument of the lid to the underlying struc-

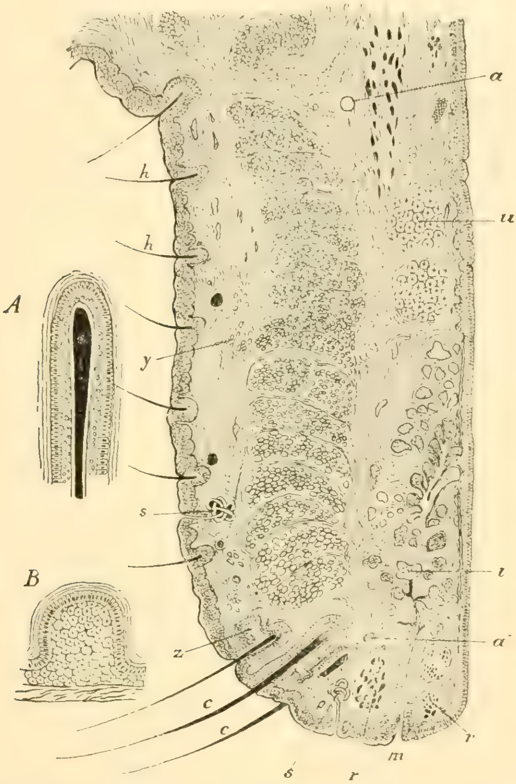

FIG. 1.—VERTICAL SECTION THROUGH THE UPPER LID. Enlarged 6 times. (H. S. Potter *del.*) The outer surface of the lid, the skin, is studded with fine hairs *h h*; imbedded init are sweat-glands, *s*, modified sweat-glands, *y*, Zeiss's glands, *z*, at the bases of the cilia, *c c*. Beneath the skin and between it and the cartilage of the lid are seen the ends of the transversely divided bundles of fibres of the orbicularis muscle; two of these bundles, *r r*, near the free margin, are Riolani's muscle. In the cartilage are imbedded the Meibomian glands, *i*, the orifices of which open on the free border of the lid just in front of its posterior sharp edge; higher up in the cartilage are Waldeyer's glands, *u*; above, on the cartilage, is the superior tarsal arch, *a*; below, the inferior tarsal arch, *a′*. The inner surface of the lid, conjunctiva, is of an adenoid character at the upper part; over the tarsus, it is papillary in nature.

tures. It differs from ordinary areolar tissue, in having no fat follicles in it. Hair follicles and sweat glands are imbedded in it.

MUSCLES.—The *muscles* entering into the structure of the

lids are: *Orbicularis palpebrarum*, palpebral portion; *musculus ciliaris Riolani; tensor tarsi* (Horner's muscle, Horner, Philadelpia, nineteenth century); *levator palpebræ superioris*, aponeurosis of; *musculus palpebralis*, superior and inferior. The last-named muscles, *musculi palpebrales*, are organic, involuntary muscles, while the others are inorganic and voluntary.

The *orbicularis palpebrarum*, the palpebral portion of which only enters into the formation of the lids, is a thin, broad, circular muscle lying just beneath the integument. The orbicular portion, or that portion that surrounds the orbit, arises in part from the internal angular processes of the frontal bone, in part from the nasal process of the superior maxillary bone, and in part from the outer surface of the inner half of the tendo-palpebrarum—a short, bifurcated tendon extending from the nasal process of the superior maxillary bone to the inner extremities of the cartilages. From this origin, the fibres, which are coarse and of a decided red color, extend in arches over the upper and lower margins of the orbits, meet at the external margin, join and form complete ellipses. In this way, a thin, flat muscle is formed, which surrounds the entire orbit and at the external margin extends for a short distance on to the temple. The orbicularis is firmly attached above to the occipito-frontalis. The tendon of the corrugator supercilii is inserted into its under surface. Below and externally, it is not so closely attached to the underlying tissue. The palpebral portion of the orbicularis arises in part from the outer bifurcated part of the tendo-palpebrarum, and in part (Horner's muscle) from the crest of the lachrymal bone, and its adjoining orbital surface, and sometimes partially from the aponeurosis closing the lachrymal groove. From this origin, the fibres from the bifurcated portion of the tendo-palpebrarum extend outward, over the tarsal cartilages and tarso-orbital fasciæ, to meet at the external commissure along a raised line (*raphe*) which extends horizontally outward from the external canthus, the fibres not joining to form complete ellipses, as did the fibres forming the orbital portion of the muscle. The fibres are very thin and pale as compared with those of the orbital portion. Those near the free borders of the lid (from their minute description by Riolanus have been called *musculus ciliaris Riolani*) extend in almost straight lines along

the cartilage to meet at an acute angle at the outer commissure, while those situated further away from the free border form arches, which are more curved as they recede from the free border. At the external commissure where they meet along the cellular raphe, they are closely bound down to the underlying fascia.

Horner's muscle, the tensor tarsi, is that part of the palpebral portion of the orbicular muscle which arises from the crest of the lachrymal bone and its adjoining orbital surface. From that origin it extends outward and divides into two slips, an upper and a lower, just in front of the lachrymal sac. From the point of bifurcation, the slips extend outward along the outer surface of the canaliculi, one joining to the inner extremity of the upper lid, and the other to the inner extremity of the lower lid, to be inserted into the free border of the cartilages near the lachrymal papillæ. Some of the fibres, before they are inserted, encircle the lachrymal puncta, while others in conjunction with a few of the pale fibres of the palpebral portion of the orbicularis, are said to extend across the cartilages near their free borders to their outer extremities, situated partly in front and partly behind the ducts leading from the Meibomian glands, and are known as the muscle of Riolanus.

The *levator palpebræ superioris* arises about one line from the upper margin of the optic foramen, just above the origin of the superior rectus muscle. It is a thin, flat, ribbon-like muscle which passes forward just beneath the roof of the orbit to be inserted into the orbital margin and anterior surface of the upper lid by a broad fan-shaped aponeurosis, which extends from one extremity of the tarsus to the other.

The *musculus palpebralis superior*, or superior palpebral muscle (Müller), is an organic, involuntary muscle. Its fibres arise from between the fibres of the inorganic voluntary muscle, levator palpebræ superioris, just before the fibres of that muscle terminate in the broad, fan-shaped aponeurosis that connects it to the upper margin of the upper lid. From this origin, the fibres pass downward between the broad aponeurosis of the levator superioris and the conjunctiva, to be inserted into the under surface of the upper margin of the upper tarsal cartilage, the attachment extending from one extremity of the lid to the

other. There is a similar muscle in the lower lid, which arises from the orbital connective tissue. These muscles act in the vertical direction only, and are supposed to perfectly join the free borders of the lids when the eyes are closed.

The function of the orbicularis muscle is to close the eyelids. Horner's muscle, a part of the palpebral portion of the orbicularis, from its position directly over the lachrymal sac and canaliculi, pulls the upper walls of these structures upward when it acts, perhaps producing a partial vacuum in the lachrymal sac, which causes the tears to be sucked into the canaliculi and sac along with the incoming air. This muscle is supposed to in this way aid materially in the drainage of the eye. It is questionable, however, if the vacuum-forming power of Horner's muscle, has a great deal to do with the drainage of the eye; the capillary action of the puncta and canaliculi, together with the action of the muscles of Riolani, Müller, and the orbicularis, performing this function in the main. The function of the levator palpebræ superioris, as its name indicates, is to elevate the upper lids. It is a direct antagonist of the orbicularis palpebrarum.

The orbicularis and Horner's muscle are innervated by the seventh nerve, the facial, the levator superioris by the third nerve, and the palpebral muscles of Müller, by the sympathetic.

The *tarsal cartilages* are not genuine cartilages, the name being an incorrect one. They are simply thin plates of dense, fibrous connective tissue, the upper one larger and crescentic in shape, the lower one smaller and elliptical. The upper one measures at its broadest part about 9½ lines in height, while the lower one at its broadest part measures only 6 lines. From their broadest part both cartilages taper gradually toward their extremities, coming to a sharp point externally, but are rounded off at the internal extremity. The orbital or attached margins of these plates of fibrous tissue are convex and very thin, passing gradually into the tarso-orbital fascia, which connects them to the margin of the orbit. The free margins are thicker and perfectly straight. When the lids are closed, the so-called tarsal cartilages and the tarso-orbital fascia connecting them to the margins of the orbit, form a complete fibrous covering for the eyes. The outer and inner end of each cartilage is connected to

the margins of the orbit, by special ligaments—the outer and inner canthal ligaments. The *outer* canthal ligament is simply a thickening into a narrow band or ligament, of that portion of the tarso-orbital fascia which extends from the outer extremity of the tarsal cartilage to the temporal margin of the orbit. The *inner* canthal ligament, *tendo palpebrarum*, is a short tendon at the inner angle of the eye. It has its origin from the nasal process of the superior maxillary bone just in front of the lachrymal groove, on a level with the lachrymal sac. Extending outward, it bifurcates just in front of the lachrymal sac, sending a branch to the inner extremity of each tarsal cartilage. Just at its bifurcation and from its posterior surface, it also gives off an aponeurosis which surrounds the lachrymal sac and is attached to the crest of the lachrymal bone.

The Meibomian glands (Meibomius, seventeenth century) are a variety of acinous glands imbedded in the cartilages of the lids, except near the free margins where they lie between the cartilages and the conjunctiva. There are thirty to thirty-five in the upper lid and they are somewhat longer than in the lower lid, where there are twenty to thirty in number. The Meibomian glands consist of small tubes lying parallel to one another, extending from blind extremities near the orbital borders of the cartilages to the free borders of the lids, their orifices opening in the free border just in front of the inner lip (*m*, Fig. 1). These tubes have secondary follicles or acini emptying into them. The walls of the tubes consist of basement membrane lined with scaly epithelium; the secondary acini are lined with polyhedral cells, the centre of the follicles also being filled with polyhedral cells which contain fat. It is by the breaking down of these cells that the sebaceous secretion is furnished.

EYELASHES.

(*Cilia.*)

The eyelashes, or cilia, are two or three rows of short thick hairs protruding from the outer rounded lip of the free margin of the lids (*c c*, Fig. 1). Those on the upper lid are longer than those on the lower and curve upward, while those on the lower lid curve downward. The roots of the cilia lie in the connective

tissue between the orbicularis muscle and the cartilage of the lid about 1–2 lines from the free border. At the root of each cilium a modified sebaceous (*z*, Fig. 1) gland opens whose contents serve to lubricate each cilium.

Blood-Vessels.—The arteries of the lids are chiefly furnished by the ophthalmic artery. The two largest branches run along near the margins of the lids on the anterior surface of the tarsal cartilages, forming two arterial arches, superior and inferior (*a a*, Fig. 1). From these arterial arches the skin, areolar tissue, muscles, fibrous tissue, and conjunctiva are supplied with blood. Free anastomoses take place in the lids between the branches from the ophthalmic artery and angular, anterior temporal, and facial arteries. The veins from the lids empty into the temporal and facial veins.

Nerves.—The trifacial (fifth) supplies the integument and conjunctiva of the lids; the third, or oculo-motor, the levator palpebræ; the facial supplies the orbicularis, Horner's muscle, and musculus ciliaris Riolani. The sympathetic supplies the musculi palpebrales.

Lymphatics.—The lymphatics of the eyelids are numerous, the conjunctiva being well supplied. They empty into the facial and submaxillary glands.

Physiology.—The chief function of the eyelids is to protect the eyeballs; they also help to maintain the eyeballs in position. Their frequent movements keep the conjunctival secretion well distributed over the front of the eye, thoroughly moistening the cornea, and prevent erosion of its epithelium.

ANATOMY OF THE LACHRYMAL APPARATUS.

The lachrymal apparatus consists of two portions: a secreting—the conjunctiva and lachrymal gland; and a conducting—the lachrymal canals, the lachrymal sac, and the nasal duct.

Secreting Portion.—The conjunctiva will be described in the section on the conjunctiva.

The *lachrymal gland* is divided into two portions: an upper, the larger, part and a lower, the accessory. The upper main portion, comprising the larger part of the gland, is almost almond-shaped, its longest diameter, which is the transverse, measuring about 7 lines. Its weight is about 11 grains. This

portion of the gland is situated in a fossa in the roof of the orbit at its upper outer angle, and is held in position by the tarso-orbital fascia. The upper surface comes in contact with the periosteum of the orbit, the under surface with the external and superior recti muscles.

The lower accessory portion of the gland is divided from the

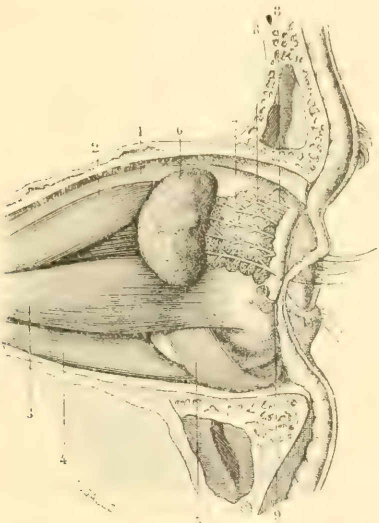

FIG. 2.—THE TWO PORTIONS OF THE LACHRYMAL GLANDS. (After Sappey.) 1, Levator palpebrarum muscle; 2, superior rectus; 3, external rectus; 4, inferior rectus; 5, inferior oblique; 6, orbital portion of the lachrymal gland; 7, palpebral portion traversed by four passages from the orbital portion; 8, accessory passages; 9, another passage occasionally present.

main portion by a fibrous septum. It consists of a group of small glands arranged in a row just above the *fornix conjunctivæ*, its anterior edge reaching to the orbital border of the upper lid at its outer half to which it is attached. This lower smaller portion of the gland is sometimes described as the accessory gland of Rosenmüller. The vessels and nerves to the lachrymal gland enter it from behind. The structure of the lachrymal gland is that of an acinous gland. Its secretion consists largely of water, some salt, and a small amount of albumin. It is carried from the gland and its accessory portion by seven to twelve very narrow ducts which open on the surface of the outer half of the superior fornix conjunctivæ. This secretion (the tears) serves to keep the surface of the eyeball moist; it is small in quantity, not being secreted faster than it is evaporated into the atmo-

sphere. The lachrymal gland actually secretes but a small portion of the tears, the conjunctiva furnishing most of them. The lachrymal gland may be extirpated without impairing the functions of the eye, the conjunctiva furnishing enough fluid to keep the eye moist. When from any cause there is an excess of tears secreted, they are carried off into the nose by the lachrymal passages. They are forced into them by the action of the

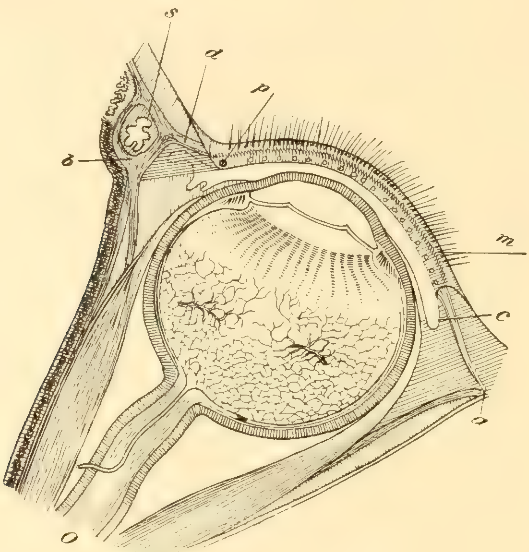

FIG. 3.—HORIZONTAL SECTION OF RIGHT ORBIT ON A LEVEL WITH THE FREE BORDER OF THE LOWER LID THROUGH THE LACHRYMAL SAC. (Modified from Fuchs.) *s*, Lachrymal sac; *b*, orbital fascia surrounding the sac; *d*, canaliculus; *p*, punctum lachrymale; *c*, cul-de-sac of conjunctiva at the outer angle of the eye; *a*, attachment of the external canthal ligament.

orbicularis and Horner's muscles. If the excess is too great to be carried off by this means, the tears run over the lids onto the face.

CONDUCTING PORTION.—The *lachrymal canals* (canaliculi) are two very small canals leading from the puncta lachrymalia on the free borders of the lids, near the inner canthus, to the lachrymal sac. They are three or four lines in length and one-half a line in diameter. From their beginning in the *puncta lachrymalia* they pass, the upper one directly upward for about 1 line, the lower one directly downward for about the same distance, then both turn inward at almost right angles to their

primary course, and proceed toward the lachrymal sac in arched courses, the concavities of the arches facing each other (see Fig. 4). Generally the two canals join, and enter the temporal side of the lachrymal sac as one tube, but they sometimes enter it independently. In structure the lachrymal canals consist of a very smooth, firm mucous membrane lined with pavement epithelium. External to this mucous membrane is a thin layer of connective tissue. The walls of these canals are elastic, and

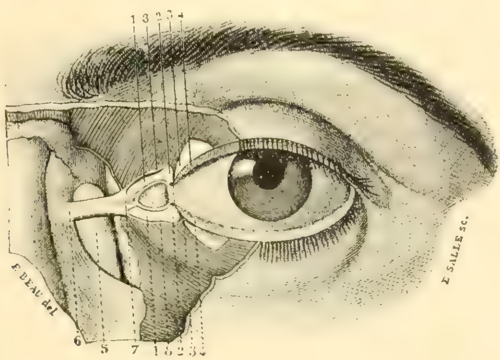

FIG. 4.—TENDON OF THE ORBICULARIS. CONNECTION OF THE TENDON WITH THE LACHRYMAL SAC AND DUCTS. (After Sappey.) 1, Lachrymal ducts; 2, beginning of these ducts; 3, internal end of the tarsal cartilages; 4, free border of the lids; 5, lachrymal sac; 6, attachment of the tendon to the maxillary bone; 7, its division into two branches; 8, the two tendons pass around the two lachrymal passages and attach themselves to the internal end of the tarsal cartilages.

the canals somewhat dilated at the angles near the puncta. Horner's muscle lies directly in front of and partly surrounds these canals.

The *lachrymal sac*, into which the lachrymal canals empty, lies in a groove formed between the lachrymal bone, and the nasal process of the superior maxillary bone at the lower inner angle of the orbit. It is slightly flattened antero-posteriorly, rounded off in a blind extremity above and continuous with the nasal duct below, where it is very much narrowed. In length, from above downward, the sac measures about 6 lines, in width about 2 lines. The rounded upper extremity of the sac extends about 1 line above the tendo palpebrarum. The transition of the sac below into the nasal duct, is usually a gradual one. Sometimes folds of mucous membrane partially obstruct the passage leading from the sac into the nasal duct. This may give rise

to difficulty in passing the lachrymal probe. The structure of the lachrymal sac consists of a rather dense, but elastic wall of connective tissue lined by a firm mucous membrane. The mucous membrane is lined by cylindrical epithelium. Between the mucous membrane and the external fibrous sheath is a venous network.

The *nasal duct* is a continuation of the lachrymal sac, from the lower extremity of which it extends through an osseous canal into the inferior meatus of the nose. The bony canal through which it extends is formed by the lachrymal, superior

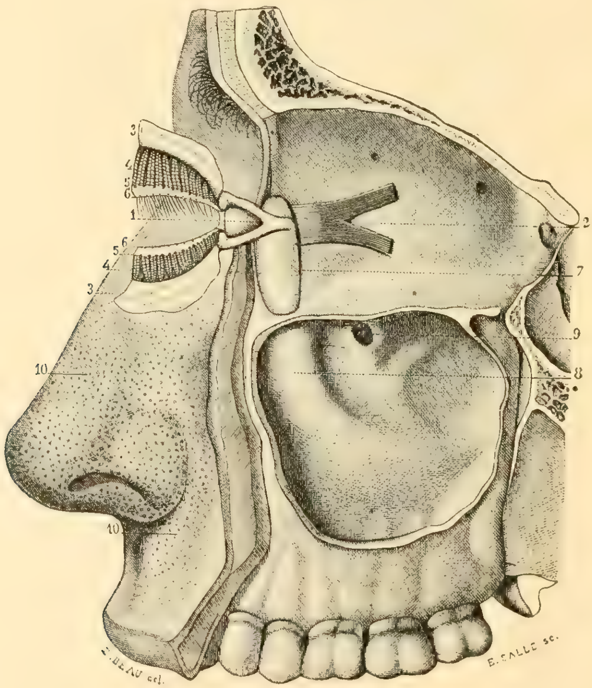

FIG. 5.—SECTION OF LACHRYMAL PASSAGES. (Sappey.) 1, Common portion of the lachrymal canaliculi; 2, Horner's muscles; 3, 3, palpebral conjunctiva; 4, 4, tarsal cartilages and Meibomian glands; 5, 5, anterior border of the lids and openings of the glands; 6, 6, posterior border; 7, lachrymal sac.

maxillary, and inferior turbinated bones. The nasal duct is about 8 to 10 lines in length, its length varying as it empties higher up or lower down in the meatus of the nose. In width it is $\frac{2}{3}$ line, but is not quite uniform throughout, the duct being a little narrower at the upper end of the osseous canal,

which also is narrowest at this point. The nasal duct in its course passes downward, backward, and outward. This fact should be kept in mind when passing the lachrymal probe. The distance between the eyes and the width of the nose alters the course of the duct in different cases. With a narrow space between the eyes and a broad, flat nose, the probe when passed takes a course downward, backward, and decidedly outward (this is often the case in negroes). With a broad space between the eyes and a narrow nose the probe passes downward, backward, and only slightly outward.

Structure.—The mucous membrane lining the nasal duct is lined by cylindrical epithelium, similar to the epithelium in the lachrymal sac; a number of mucous glands are also found scattered throughout the mucous membrane of the duct. The lower end of the nasal duct is, in many instances, partially closed by a fold of mucous membrane (valve of Hasner). Just external to the mucous membrane of the duct, and surrounding it, is a thick network of veins. External to this network of veins, and between it and the osseous canal, is a thin fibrous sheath. Engorgement of the venous layers of the duct from any cause may, temporarily, result in a complete closure of the duct. This often occurs in lachrymal catarrh. This should be borne in mind in determining the treatment in these cases. When the obstruction of duct is not due to bony constriction or necrosis, but to simple engorgement of the venous layer, injections may be tried before cutting the puncture and probing are resorted to, yet even here probing will usually be required.

Blood-Vessels.—The lachrymal gland has a special artery, the lachrymal, from the ophthalmic. It has also a branch from the infra-orbital of the internal maxillary. The lachrymal sac and duct are supplied by nasal and palpebral arteries from the ophthalmic, and by the angular artery the termination of the facial.

Nerves.—The lachrymal gland has a special nerve, the lachrymal, from the fifth nerve, and branches from the sympathetic. The lachrymal sac and duct receive branches from the fifth, seventh, and sympathetic.

Physiology.—The function of the lachrymal gland is to secrete tears which keep the eyes moist, and prevent friction

between the lids and globe of the eye. The tears have an antiseptic quality, while their continued moistening of the eye keeps it free from dust. The function of the lachrymal canals, sac, and duct is to carry off the excess of tears.

ANATOMY OF THE MUSCLES OF THE EYEBALL.

Six muscles, four straight (*recti*) and two oblique, give to the eye its varied motions. They are:

1. Superior rectus; 2. Inferior rectus; 3. Internal rectus; 4. External rectus; 5. Superior oblique; 6. Inferior oblique. They are termed the extrinsic muscles of the eye, while the ciliary muscle and sphincter muscle of the iris are designated the intrinsic muscles of the eye.

The four recti or straight muscles, arise immediately around the optic foramen, partly from a tendinous ring (ligament of Zinn) which surrounds the lower and inner margin of the optic foramen, and partly from the margin of the optic foramen itself. From this origin they pass forward, diverging as they go on, and come in contact with the eyeball just behind its equator. Keeping in contact with it, they pierce its sheath (Tenon's capsule) from $\frac{1}{8}$ to $\frac{1}{3}$ inch back of the sclero-corneal margin, to become inserted into the sclerotic by tendinous expansions—one above, one below, one to the outer side and one to the inner side.

The *superior rectus*, is the smallest and thinnest of the four recti muscles. It arises from the upper margin of the optic foramen, just below the origin of the *levator palpebræ superioris* (*su*, Fig. 6); some fibres also spring from the sheath of the optic nerve. From this origin it passes forward, slightly outward, just beneath the levator superioris palpebræ, and almost parallel with the roof of the orbit, terminating anteriorly in a tendon about four lines broad, convexed anteriorly. This tendon is inserted obliquely into the upper part of the sclerotic, its inner edge about three lines and its outer edge about four lines from the margin of the cornea (*b*, Fig. 6).

The *inferior rectus*, arises from the ligament of Zinn at the lower margin of the optic foramen (*in*, Fig. 6), runs forward, slightly outward, and parallel with the floor of the orbit, terminating anteriorly in one tendinous aponeurosis about three lines broad, which is convexed anteriorly, and inserted obliquely into

the lower portion of the sclera, its inner edge two and a half lines and its outer edge three and a half lines from the margin of the cornea (*c*, Fig. 6).

The *internal rectus* is the strongest and broadest of the recti muscles. It arises partly from the ligament of Zinn, and partly from the inner margin of the optic foramen (*it*, Fig. 6), passes forward, very slightly inward, almost parallel with the inner wall of the orbit to terminate in a tendinous aponeurosis about four and a half lines broad, convex anteriorly, which is inserted

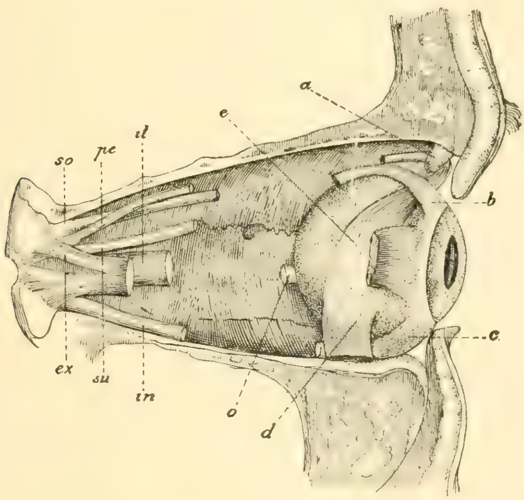

FIG. 6.—ORIGIN AND ATTACHMENT OF THE OCULAR MUSCLES. (H. T. Potter *del.*) *so*, Superior oblique; *pe*, levator palpebræ superioris; *su*, superior rectus; *it*, internal rectus; *ex*, external rectus; *in*, inferior rectus; *b*, attachment of superior rectus; *c*, attachment of inferior rectus; *a*, pulley for superior oblique; *e*, attachment of superior oblique; *d*, attachment of inferior oblique; *o*, optic nerve entrance.

into the inner portion of the sclera three lines from the margin of the cornea and on a level with the centre of the cornea.

The *external rectus* is the longest of the recti muscles, and has a double origin or two heads. The upper head arises from the upper part of the outer margin of the optic foramen (*ex*, Fig. 6), the lower head from the ligament of Zinn and from a small process of bone on the under margin of the sphenoid fissure. The two heads unite after running a short distance, pass forward, outward, curving around the outer side of globe of eye to terminate in a tendinous aponeurosis about three and a half lines broad, convexed anteriorly, which is inserted into the outer

portion of the sclera three and a half lines from the margin and on a level with the centre of the cornea.

The *superior oblique* arises just above, and internal to, the origin of the superior rectus, about one line from the upper margin of the optic foramen (*so*, Fig. 6). It passes forward, upward, and inward to the upper inner angle of the orbit, to a pulley (*a*, Fig. 6) formed of fibrous tissue situated in the depression just under the internal angular process of the frontal bone, through which it passes as a tendon, the tendon being separated from the pulley by a delicate synovial membrane which is inclosed in a fibrous sheath. After passing through this pulley it is deflected downward, outward, and backward beneath the superior rectus to be inserted by a fan-shaped aponeurosis about 3 lines broad into the sclera about half-way between the superior and external recti muscles, and nearer to the optic nerve than to the cornea, the anterior edge of the aponeurosis being about five lines from the cornea, while the posterior edge is about four lines from the optic nerve (*e*, Fig. 6).

The *inferior oblique* arises from a depression in the anterior inner part of the orbital plate of the inferior maxillary bone, just external to the opening for the nasal duct. From this origin it runs outward and backward, passing between the floor of the orbit and the internal rectus; it then turns upward between the external rectus and the eyeball, to be inserted into the sclera, near the insertion of the superior oblique and on a line with it, by a fan-shaped aponeurosis about five lines broad. The anterior edge of the aponeurosis is about five lines from the cornea, while the posterior edge is about two lines from the optic nerve (*d*, Fig. 6).

Before the tendons of any of these muscles, recti or oblique, are inserted into the sclera they pierce the capsule of Tenon. This capsule is reflected as a sheath backward along the tendons for a short distance. This fact should be remembered in tenotomy of these muscles for strabismus, for although a complete division of the muscle may be made, unless this capsule fibre sheath is divided and the capsule dissected up somewhat, the will effect be lessened.

The exact origin, course, and the exact manner and position of insertions of these muscles should be fixed clearly in the mind,

for upon this knowledge the clear understanding of their actions depends.

PHYSIOLOGY.—The function of the six muscles just described is to move the eyes in different directions, so that moving objects or objects occupying different positions in space in relation to the eyes, can be fixed or brought into the field of vision. Before describing the separate and combined actions of these muscles, it is necessary first to fix certain points, lines, planes, and axes in connection with the eyeballs, and the relation these points, lines, planes, and axes bear to the eyes, the muscles which move them, and the orbits within which they move. In other words, we should ascertain the centre of motion around which, and the axes upon which, the eyeballs rotate, and the relation they bear to the surrounding parts and the objects viewed.

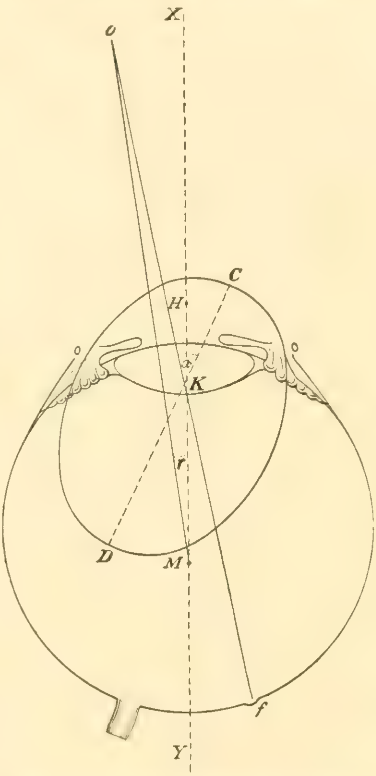

FIG. 7.—SHOWING DIFFERENT LINES AND POINTS OF THE EYE. (H. T. Potter *del.*) *XY*, Optic axis; *H*, principal points combined; *K*, nodal points combined; *M*, centre of motion; *fO*, line of vision; *MO*, line of fixation; *CD*, greater axis of corneal ellipsoid; *OKC*, angle α; *OMX*, angle γ. This figure is very diagrammatic. In order to show the angles α and γ plainly, the long axis of corneal ellipse should, and practically does, coincide with the optic axis of the eye.

The *optic axis*, or antero-posterior axis of the eyeball, is the line joining the anterior and posterior poles of the eye, practically coinciding with the line of vision (*XY*, Fig. 7). Movements around this axis are chiefly accomplished by the oblique muscles, partly by the superior and inferior recti, and are designated rotary movements.

The *transverse axis* of the eyeball is a line drawn through the horizontal meridian of the eye, at right angles to the optic axis and through the centre of motion (*CD*, Fig. 8). The movements around this axis are vertical chiefly, and are ac-

complished by the inferior and superior recti assisted by the oblique muscles.

The *vertical axis* of the eyeball, is a line drawn through the vertical meridian of the eyeball, perpendicular to the optic axis, through the centre of motion. The movements of the eye about this axis are horizontal, and are accomplished by the external and internal recti muscles.

The *vertical meridian* of the eye is the line drawn along the surface of the eyeball from the upper extremity of the vertical axis to the centre of the cornea, to the lower extremity of the vertical axis, around the posterior surface of the ball to the upper ex-

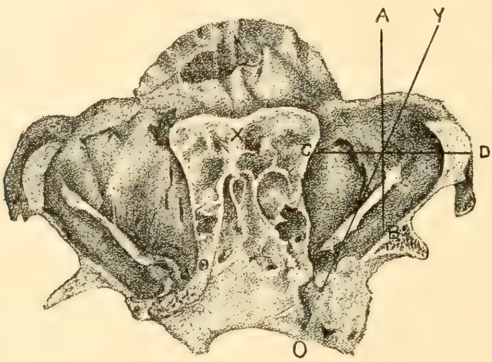

FIG. 8.—HORIZONTAL SECTION THROUGH THE ORBITS ON A LEVEL WITH THEIR CENTRES. (H. T. Potter *del.*) *OY*, Orbital axis; *CD*, horizontal or frontal axis of eyeball; *AB*, antero-posterior axis of eyeball, or optic axis.

tremity of the vertical axis, the starting-point. The *horizontal meridian* is the line drawn along the surface of the eyeball, from the inner extremity of the transverse axis to the centre of the cornea, to the outer extremity of the transverse axis, around the posterior surface of the eye to the starting-point. The *equatorial meridian* of the eye, is the line drawn transversely along the surface of the eye joining the four extremities of transverse and vertical axes. The *centre of motion* of the eyeball, which is stationary, and around which all the motions of the eye take place, is situated on the optic axis about one line posterior to its centre (*M*, Fig. 7). The *base line* is the line joining the centres of motion of the two eyes. The *meridian plane* is the plane passed through the vertical axis of the head and the centre of the base line. The *visual plane* is a plane passed through the

base line and the visual lines. The *visual lines* are the lines extending from an object seen by the eyes, through the nodal points (centre of curvature of refractive surfaces of each eye) to the macula lutea in each eye (fO, Fig. 7). The *line of fixation* is the line extending from the object fixed to the centre of motion of the eye (MO, Fig. 7). The *angle* α (alpha) (OKC, Fig. 7) is the angle formed by the visual line and the long axis of the corneal ellipse, which axis practically coincides with the optic axis of the eye. The *angle* γ (gamma) (OMX, Fig. 7) is the angle formed by the line of fixation and the optic axis of the eye. The *muscle plane* is the plane passed through the line joining the centre of origin and insertion of a muscle and the centre of motion of the eye. The muscle plane is important in determining the action of each muscle on the eye. Each muscle, when acting independently, moves the eye around an axis drawn through the centre of motion of the eye, perpendicular to the plane of that muscle. This axis is called the *axis of turning* of that muscle—*e.g.*, the axis of turning of the external or internal rectus muscle, is the vertical axis of the eye.

The *primary position* of the eye is that in which all the muscles (extrinsic) are in a state of equilibrium, the visual lines horizontal and parallel to the median plane, and the head erect. All other positions of the eyes are termed *secondary*.

With the above landmarks, so to speak, of the movements of the eyes, the action of separate or of two or more muscles at one time may be readily understood. Furthermore, in considering the movements of the eye, it should be remembered, that the *centre of motion* [1] remains stationary, while the *centre of the cornea* and the *upper extremity of the vertical meridian*, are the points on the eye from which their movements are measured. For example, the distance and direction of the centre of the cornea and the position of the upper extremity of the vertical meridian in any secondary position, from what they were in the primary position, gives the position of the eyes in the second position.

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[1] There is a very slight backward movement of the centre of motion, when all the recti muscles contract at one time, and a slight forward motion of this point when all are relaxed. Both these movements are so slight that they are not to be considered.

Action of the separate muscles:

The *internal rectus* acting by itself pulls the eye directly inward, rotating it around its vertical axis. The centre of the cornea moves along the horizontal meridian a distance of about 44°, while the vertical meridian remains perpendicular.

The *external rectus* acting alone pulls the eye directly outward, rotating it, as did the internal rectus, around its vertical axis. The centre of the cornea moves along the horizontal meridian a distance of about 43°, while the upper extremity of the vertical meridian remains perpendicular.

The external and internal recti muscles, are the only muscles acting singly that give to the eye a simple motion, that is, which move the centre of the cornea without changing the position of the upper extremity of the vertical meridian. Any motion of the eye that, at the same time, changes the centre of the cornea and the upper extremity of the vertical meridian is a *compound* motion.

The *superior rectus*, acting singly, pulls the eye up and in, at the same time rotating the upper extremity of the vertical meridian inward around a secondary axis which is perpendicular to its muscle plane through the centre of motion. A consideration of the origin and insertion of this muscle makes its action understood. From its origin at the apex of the orbit, it passes forward and outward at an angle of about 20° with the optic axis, to be inserted obliquely into the sclera above. Acting through its muscle plane, which slants inward from the optic axis, it must pull the eye (centre of cornea) upward and inward, at the same time it rotates the upper extremity of the vertical meridian inward.

The *inferior rectus*, acting alone, pulls the eye downward and inward, at the same time it rotates the upper extremity of the vertical meridian outward, around a secondary axis at right angles to its muscle plane through the centre of motion. Acting through its muscle plane, which is at the same angle with the optic axis (20°) as is the plane of the superior rectus, it pulls the eye (centre of cornea) downward and inward, and rotates the upper extremity of the vertical meridian outward.

The *superior oblique*. In considering the action of this muscle, its origin, so far as its action on the eyeball is concerned,

is the same as if it arose from the pulley at the upper inner angle of the orbit, through which it plays. From this physiological origin, it passes downward, outward, and backward to its point of insertion on the posterior and outer surface of the sclera—its muscle plane extending from the pulley to the point of insertion of the muscle. Acting through this plane, its chief function is to rotate the upper extremity of the vertical meridian inward. Its point of insertion being lower than its point of origin, it also turns the centre of the cornea downward and outward, by the mere act of pulling the posterior portion of the eye upward and inward.

The *inferior oblique* acting alone through its muscle plane, from its point of origin at the lower inner angle of the orbit to its point of insertion on the posterior outer surface of the sclera, rotates the upper extremity of the vertical meridian outward, at the same time, its point of insertion being higher than point of origin, it turns the centre of the cornea upward and outward.

Having considered the separate actions of the different muscles, it is now necessary to consider some movements of the eyes in which more than one muscle is brought into play.

The *direct upward movement* of the eye, is accomplished by the combined action of two muscles, the superior rectus and inferior oblique. The superior rectus pulls the eye (centre of cornea) upward, but at the same time inward, also rotating the upper extremity of the vertical meridian inward. To counteract the inward movement of the cornea, and the upper extremity of the vertical meridian, a second muscle possessing the power to move these points in an opposite direction must be called into play, and this muscle is the inferior oblique. It also moves the eye upward. The combined action of the two is to move the centre of the cornea directly upward along the vertical meridian, this meridian remaining vertical.

The *direct downward movement* of the eye, is brought about by the inferior rectus and the superior oblique, the inferior rectus pulling the eye downward and inward, at the same time rotating the upper extremity of the vertical meridian outward. To counteract the inward movement of the centre of the cornea, and the outward movement of the upper extremity of the vertical meridian, and at the same time assist in the downward

movement of the cornea, a second muscle is brought into action —the superior oblique. The opposing actions of the two muscles are equalized while the similar action, downward, is increased, and the centre of the cornea is moved directly downward along the vertical meridian, the upper extremity of this meridian remaining vertical.

The *upward and inward movement* of the eye is accomplished by the combined actions of three muscles—the superior rectus, internal rectus, and inferior oblique. The opposite eye moves upward and outward at the same time. The vertical meridians in both eyes are inclined and parallel; the one in the eye that is looking upward and inward (which we will assume to be the right) is inclined inward, while in the opposite eye it is inclined outward. The right internal rectus and the superior rectus, acting together, move the centre of the cornea upward and inward along a diagonal between the two muscles. The superior rectus also rotates the upper extremity of the vertical meridian inward. To prevent too great rotation inward of the vertical meridian, and to keep it parallel with the vertical meridian in the left eye, which is inclined slightly outward, and at the same time to help move the eye upward, a third muscle is brought into action—the inferior oblique.

The *upward and outward movement* in the left eye (in the above case) is brought about by the combined actions of the left external and superior recti, and the inferior oblique muscles. The external and superior recti acting in conjunction, move the centre of the cornea upward and outward along a diagonal between the two muscles. The superior rectus also rotates the upper extremity of the vertical meridian inward. To counteract this tendency, and to rotate the upper extremity of the vertical meridian outward, keeping it parallel with the right vertical meridian, and also to assist in moving the eye upward, a third muscle is brought into play—the inferior oblique.

The *downward and inward movement* of the eye (right, the left being moved downward and outward at the same time) is brought about by three muscles, the inferior and internal recti and the superior oblique. The vertical meridians remain parallel, the upper extremities of both being tilted to the right. The right inferior and internal recti acting conjointly pull the centre

of the cornea downward and inward along a diagonal between the two muscles. The inferior rectus rotates the upper extremity of the vertical meridian outward at the same time. To prevent a too far outward rotation of the vertical meridian and to maintain it parallel with the left, also to assist in the downward movement of the eye, a third muscle comes into action—the superior oblique.

The *downward and outward movement* in the left eye (in last example) is brought about by the inferior and external recti and the superior oblique muscles. The inferior and external recti acting conjointly pull the eye downward and outward, along a diagonal between the two muscles. The inferior rectus also has a tendency to rotate the upper extremity of the vertical meridian outward. To counteract this tendency and to rotate the upper extremity of the vertical meridian inward, to have it parallel to the right vertical meridian, and to help move the eye downward, a third muscle is called into action, the superior oblique.

Soelberg Wells[1] has given a brief summary of the movements of the eye and the muscles accomplishing these movements, as follows:

Movement.	*Muscles.*
Inward	Int. rectus.
Outward	Ext. rectus.
Upward	Sup. rectus and inf. oblique.
Downward	Inf. rectus and sup. oblique.
Upward and inward	Sup. and int. recti and inf. oblique.
Upward and outward	Sup. and ext. recti and inf. oblique.
Downward and inward	Inf. and int. recti and sup. oblique.
Downward and outward	Inf. and ext. recti and sup. oblique.

BLOOD-VESSELS.—The muscular branches from the ophthalmic artery supply the six extrinsic muscles of the eye. The venous blood returned from the muscles is emptied into the ophthalmic and facial veins.

NERVES.—The sensory nerves are from the fifth, chiefly from its ophthalmic division, the orbital branch from the middle division, however, assisting.

The motor nerves to the different muscles are:

The third or oculo-motor. Besides supplying the intrinsic

[1] "Diseases of the Eye," edited by C. S. Bull, p. 676.

muscles of the eye it supplies the superior, internal, and inferior recti muscles and the inferior oblique. The origin of the third nerve is from nuclei lying beneath the aqueduct of Sylvius, in the floor of the fourth ventricle on both sides of the meridian raphe, and in a line under but slightly anterior to the corpora quadrigemina. It is in the anterior portion of the nucleus of the third nerve, that the centres of motion of the pupil, accommodation and convergence in the order named—(Kahler, Fuchs) are found, while the centres of motion of the inferior and superior recti and the inferior oblique are situated further back in the nucleus. From this origin the nerve runs downward and outward through the crus cerebri to the base of the brain, being surrounded by a sheath of pia mater for a short distance on emerging from the crus. It then pierces the dura mater, extends along the outer wall of the cavernous sinus, entering the orbit through the sphenoidal fissure between the two heads of the external rectus muscle. In the cavernous sinus it receives some sympathetic nerve branches from the cavernous plexus. On or before entering the orbit, it divides into two main divisions. The superior branch supplies the superior rectus, also the levator palpebræ superioris. The inferior branch usually subdivides into three branches, one for the internal rectus, one for the inferior rectus, and one for the inferior oblique. It is from this last branch that the motor branch to the lenticular ganglion is supplied.

The fourth, or trochlear nerve, supplies the superior oblique muscle. Sometimes it gives off a branch to help form the lachrymal nerve, and many times a recurrent branch to the meninges. Its origin is in the floor of the fourth ventricle just beneath and back of the origin of the third nerve. From this origin the nerves pass upward into the valve of Vieussens, in which fibres from the two trunks decussate, thus joining the two nerve trunks in the brain near their origin. From here they separate, winding around the outer side of the crus cerebri, pierce the dura mater to enter the cavernous sinus, along the outer wall of which they run, receiving some sympathetic branches from the cavernous plexus in their course. It enters the orbit through the sphenoidal fissure high up, and runs forward and upward to supply the superior oblique muscle.

The sixth, or *abducens* (*pulling out*) nerve supplies the external rectus. Its origin is from a nucleus in the floor of the fourth ventricle just below the nucleus of the seventh nerve, both being situated in the fasciculus teres and just in front of striæ medullares. From this origin, the nerve passes downward and outward between the posterior surface of the pons Varolii and the anterior surface of the medulla, to enter the cavernous sinus, through which it runs, entering the orbit through the sphenoidal fissure between the two heads of the external rectus muscle. While in the cavernous sinus, it receives a communicating branch from Meckel's ganglion, one from the ophthalmic branch of the fifth nerve, besides several sympathetic branches from the cavernous and carotid plexuses. In the orbit it supplies but one muscle—the external rectus.

There are special centres governing the co-ordinate actions of the ocular muscles, while their voluntary actions are governed by centres situated in the cortex of the brain.

CHAPTER II.

THE ANATOMY AND PHYSIOLOGY OF THE CONJUNCTIVA AND CORNEA, THE SCLERA, AQUEOUS AND VITREOUS HUMORS AND CRYSTALLINE LENS.

Anatomy of the Conjunctiva.—General Description.—Histological Elements.—Structure.—Fornix Conjunctiva.—Ocular Conjunctiva.—Plica Semilunaris.—Membrana Nictitans.—Caruncle.—Blood-Vessels.—Nerves.—Functions.—The Cornea.—Histological Elements.—Layers.—Nerves.—Physiology.—The Sclera.—Aqueous Humor.—The Vitreous Humor.—The Crystalline Lens.

THE CONJUNCTIVA.

(*Conjungere, to join together.*)

THE conjunctiva is the mucous membrane lining the inner surfaces of the eyelids, and covering the anterior half of the eyeball, from the equator to the margin of the cornea. It encroaches upon the margin of the cornea, when it is called *limbus conjunctivalis* (*limbus, margin*), and its epithelial layer, becoming transparent, extends entirely across the cornea, forming the anterior layer of that structure. At the free borders of the lids, the conjunctiva has its origin as a direct continuation of the external integument of the lids. It is closely adherent to the posterior surfaces of the tarsal cartilages by a dense cellular tissue. This portion of the conjunctiva is known as the *palpebral conjunctiva.*

From the posterior or orbital borders of the lids, it is reflected in loose folds, *fornix* (*arch*) *conjunctiva.* Going forward it comes upon the eyeball just in front of the equator, from which point forward to the cornea, it is loosely attached to the globe of the eye by cellular connective tissue. This portion is known as the ocular conjunctiva. At the inner canthus (*corner*) of the eye, the ocular conjunctiva forms a crescentic fold with a concavity toward the cornea. From its shape this fold is called *plica* (*plait*) *semilunaris.* Just internal to this fold of the conjunctiva, resting partly in its anterior surface, and fill-

ing up the depression—*lacus* (*lake*) *lachrymalis*—at the inner canthus, is a small, red, fleshy mass—*caruncula lachrymalis.*

Histological Elements.—These are: connective-tissue corpuscles; intercellular substance; elastic fibres; papillæ; epithelium; cup cells or follicular glands; acinous and conglomerate glands; lymphatics, and lymph corpuscles; blood-vessels; nerves.

Structure.—Like other mucous membranes, the conjunctiva has a basis of adenoid tissue, which is bound to the underlying tissue by cellular connective tissue. It is covered by epithelium. The structure of the conjunctiva, however, is not the same throughout, but it varies in different portions according to its situation, both as to the character and arrangement of its elements. The different portions will, therefore, be described separately.

The *palpebral conjunctiva* covering the inner surfaces of the lids is dense, opaque, and very vascular, the blood-vessels being clearly outlined here and there. Its surface, covered by papillæ, is of a yellowish-red color, irregularly checked or marked by shallow furrows, that run in every direction. These papillæ are absent from the free border of the lids. Beginning about one millimetre from the free border of the lids as very fine elevations, they gradually increase in size toward the orbital border, where they can be seen by the naked eye. It has been questioned if they are true papillæ, the loop-ending blood-vessels found in true papillæ often being absent in those of the conjunctiva (Wolfring). In severe inflammations of the conjunctiva, these papillæ become greatly swollen, and impart to it the well-known velvet-like appearance and feel. Opening on the surface of the palpebral conjunctiva, between the epithelial cells, are some very narrow ducts which are the mouths of the *cup cells* (Henle, Germany, nineteenth century). These cells are simply convolutions of the basement membrane of the conjunctiva lined by cylindrical epithelium. They secrete mucus to assist in lubricating the lids. The epithelium covering the palpebral conjunctiva is chiefly pavemented, the deeper layers approach to the round and cylindrical in form. At the edges of the lids, the palpebral conjunctiva is continuous with the lining membrane of the Meibomian glands, and at the outer end of the upper lid,

with the lining membrane of the lachrymal ducts, into the lachrymal glands, and through the lachrymal puncta and lachrymal canals into the lachrymal sac and nasal duct. The blood-vessels and nerves are more numerous in this portion of the conjunctiva than in any other, except in the *limbus conjunctivæ* (see Fig. 1, for section of this portion).

The fornix conjunctiva is the loose fold of conjunctiva reflected from the orbital border of the lids, forming a cul-de-sac above and below, the upper one being the deeper. Both are deeper at the outer extremity than at the inner. They are sometimes called the *superior* and *inferior* palpebral folds. This is the thickest portion of the conjunctiva. It is loose in texture, contains many elastic fibres, and is attached to the underlying orbital tissue by very loose cellular connective tissue. It is covered by cylindrical epithelium, and near the orbital borders of the lids contains a number of large papillæ. Lymphatic follicles are present in both of the culs-de-sac. These are the so-called "frog spawn" follicles characteristic of follicular trachoma. Conglomerate glands similar in structure to the lachrymal gland, sometimes called *accessory lachrymal glands*, are also found in the culs-de-sac (Krause). In the superior cul-de-sac, especially numerous at its outer extremity, are a number of tubular acinous glands lined with squamous epithelium (Waldeyer, Germany, nineteenth century). The secretion from them is almost identical with that from the lachrymal gland, but it is much more abundant. In fact, the fluid that keeps the eye constantly moist, is from these glands and the conjunctival vessels, and not from the lachrymal gland—the secretion from the latter gland being called into play only on special occasions, as when crying. The lachrymal gland may be removed, and the comfort and usefulness of the eye not impaired. However, should the secretion from the conjunctival vessels and acinous glands be stopped, the conjunctiva would become dry, the epithelium from the cornea peel off, and the eye be lost. The blood and nerve supply to this portion of conjunctiva is very abundant.

The ocular conjunctiva is that portion covering the anterior half of the globe of the eye. It extends from just in front of the equator to the margin of the cornea, and across it as the

epithelial layer of that structure. It is covered by pavement epithelium, has no glands and but few papillæ. It is the thinnest portion of the conjunctiva, semi-transparent and freely movable owing to its loose connection to the globe of the eye by loose connective tissue. Its blood and nerve supply is not as abundant as to the palpebral portion. There is a zone of lymphatics just back of the cornea, which ramify throughout the conjunctiva. The *plica semilunaris*, is a crescentic fold of conjunctiva at the inner angle of the eye. It corresponds to a similar structure much better developed in some of the lower animals, and to the third eyelids of birds, *the membrana nicti tans.* Some smooth muscle fibres have been found in this fold. In birds, a narrow plate of cartilage sometimes exists in the fold.

The *caruncula lachrymalis*, is a small, red body resting partly in the anterior surface of the *plica semilunaris*, at the inner canthus of the eye. It is composed of follicles resembling in structure the Meibomian glands, modified sebaceous glands, fat cells, hair follicles, the whole being woven together by connective tissue. It secretes a whitish material, often present at the inner angle of the eye, especially in the aged.

Blood-Vessels.—The conjunctiva is rich in blood-vessels. From the *orbital* group of the ophthalmic artery it receives blood from the following branches: the lachrymal, palpebral, frontal, nasal, and supra-orbital; the muscular and anterior ciliary, from the *ocular* group of the ophthalmic; the angular, from the *facial;* the infra-orbital, from the internal maxillary; and, by anastomosis, from the anterior temporal, middle temporal and transverse facial. The distribution of blood to the palpebral conjunctiva is chiefly from the arterial arches—two for the upper, one for the lower lid—which lie on the anterior surface of the tarsal cartilage near the borders (see cut on p.). From these arches numerous small branches are given off which must pierce the cartilage before reaching the palpebral conjunctiva. The fornix conjunctivæ also receives many arterial branches from the arches at the orbital borders of the lids. The arteries in the fornix conjunctivæ continue directly into the ocular conjunctiva, supplying it with most of its blood. The anterior ciliary arteries, however, from the four recti muscles, before piercing the sclera just back of the cornea, give off branches, which

supply the ciliary region of the ocular conjunctiva, and anastomose with the vessels from the posterior portion of the conjunctiva. Loop-ending branches from the anterior ciliary arteries extend into the limbus conjunctivæ, and form an important factor in the nutrition of the cornea. The veins of the conjunctiva empty into the temporal, the angular of the facial, and the ophthalmic. The veins from the limbus conjunctivæ, and the anterior portions of the ocular conjunctiva corresponding to the anterior ciliary arteries, empty chiefly into the anterior ciliary veins. The blood-vessels of the conjunctiva are superficial and deep. The superficial vessels of the ocular conjunctiva move when that membrane is moved, and are easily distinguished from the deeper vessels in the sub-conjunctival cellular tissue, which do not move at all, and which disappear near the margin of the cornea.

Nerves.—The nerves of the conjunctiva, like the blood-vessels, are also abundant and in the same parts, the palpebral and limbus conjunctivæ being the most abundantly supplied. The ophthalmic, the smallest branch of the fifth (trigeminus), is the chief source of supply. The lachrymal and nasal branches from this division of the fifth supply the conjunctiva of the upper lid, the superior cul-de-sac, and the ocular conjunctiva. The ocular and palpebral branches from the superior maxillary, the second division of the fifth, supply the conjunctiva of the lower lid. The exact termination of the nerve filaments in the conjunctiva is yet a disputed point. Club-shaped endings have been found (Kölliker), but most of the fibres have free endings between the epithelial cells. These nerves are closely associated with the ciliary nerves, as are also branches of the ophthalmic, which supply the ciliary muscle and iris. The spasm of accommodation, often present when the conjunctiva is inflamed, is explained by this close association. Indirectly, through the ciliary nerve, a severe inflammation of the conjunctiva, may even lead to irritation of the retina.

Physiology.—Besides helping to retain the eye in position, the main function of the conjunctiva, is to form a covering for the inner surfaces of the eyelids and the outer surface of the anterior half of the eyeball, and, by its secretion, to keep the opposing surfaces moist and lubricated, allowing of free move-

ment without friction, at the same time preserving the delicate structure and clearness of the cornea, by keeping it always moist.

THE ANATOMY OF THE CORNEA.

(*Cornu, a horn.*)

The cornea forms the anterior one-sixth of the external surface of the eye. It is a perfectly clear, transparent membrane and ellipsoidal in shape. Its shape is due to an overlapping of the margins of the cornea, above and below, by the sclera. As a rule, the transverse diameter is the longer and less curved, while the vertical diameter is shorter and more curved. This fact is daily confirmed by measurements with the ophthalmometer. The fibrous tissue of the cornea, is a direct continuation from that of the sclera, but the cornea projects out from the sclera in front like the segment of a smaller sphere from a larger one, or as a watch-crystal from its case. The cornea is slightly thinner at its centre ($\frac{1}{28}$ inch thick) than at the periphery where it is $\frac{1}{22}$ inch in thickness. The refractive index is variously estimated from 1.3365 (Helmholtz) to 1.342.

Histological Elements.—Fibrous connective tissue; cement-like substance; corneal corpuscles—flat, fusiform, branched, and lymphoid, or the so-called wandering corpuscles of the cornea; epithelium and endothelium; nerves; loops of blood-vessels at the periphery.

Structure.—From without inward, the cornea is composed of five layers.

1. *Epithelial layer*, continuous from the conjunctival epithelium.
2. *Anterior limiting membrane*, Bowman's or Reichert's membrane.
3. *True corneal tissue*, a transparent, fibrous tissue.
4. *Posterior limiting membrane*, or elastic lamina, Descemet's membrane.
5. *Endothelial layer*,[1] a single layer of polygonal cells, lining the posterior surface of Descemet's membrane.

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[1] This layer is usually incorrectly called the posterior epithelial layer. But as the polygonal cells on the posterior surface of Descemet's membrane, line a serous cavity—the anterior chamber—they are in fact endothelial, not epithelial, cells.

The epithelial layer (*e*, Fig. 9), is a continuation of the conjunctival epithelium upon the cornea.

There are several strata or layers of these epithelial cells: the most anterior layers are squamous in character with flattened nuclei. The next layers make a gradual transition from squamous to fusiform, while the deepest layers approach in shape to the columnar, and rest vertically on the underlying basement (Bowman's) membrane. The epithelial layer is very thin, $\frac{3}{2500}$ inch thick, and quite transparent.

The anterior limiting membrane (*b*, Fig. 9), of Bowman, the next layer of the cornea, is a firm, dense, perfectly transparent membrane. It is fibrillar in structure, being formed of very delicate fibrils of the same fibrous tissue that enters into the formation of the true corneal tissue, but is denser than this, and has no corneal corpuscles in it. By some, this layer is considered a true, homogeneous, hyaline membrane. It is not easily affected by chemical agents. In thickness it varies from $\frac{1}{5000}$ to $\frac{1}{2500}$ of an inch.

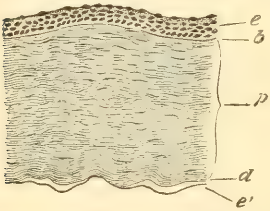

Fig. 9.—Vertical Section of the Cornea. (H. T. Potter *del.*) *e*, Epithelial layer; *b*, Bowman's membrane; *p* true corneal tissue; *d*, Descemet's membrane; *e'*, endothelial cells lining Descemet's membrane.

The true corneal tissue (*p*, Fig. 9), lying between Bowman's membrane in front and Descemet's membrane behind, forms the greater thickness of the cornea, measuring about $\frac{1}{25}$ inch in thickness. It is composed of delicate, transparent, fibrous connective-tissue fibrillæ, which are joined into bundles and these again into lamellæ, fifty to sixty in number. The fibres of each lamella run parallel to one another and to the surface of the cornea, but at right angles to the lamellæ in front and back of it. Fibres often pass from one lamella to another at an acute angle. This fibrous tissue forming the cornea proper, is a direct continuation from the sclera, of the fibrous connective tissue, the essential difference between the two is, that the corneal lamellæ are transparent, while the scleral are opaque.

The fibrillæ, bundles, and lamellæ are joined together by a semi-fluid, *cement-like substance*, in which are left numerous star-shaped spaces (*corneal spaces*), which are connected to one another by narrow canals. Each corneal space contains a cell

—*corneal corpuscle*—which gives off delicate processes, to join processes from other cells. These corpuscles are nucleated and filled with a granular protoplasm. In the corneal spaces and the canals joining the spaces are also found *wandering cells* (Engelmann), which are claimed to be lymphoid corpuscles; they are in constant motion, having amœboid qualities.

The posterior limiting membrane or elastic lamina (*d*, Fig. 9), generally known as Descemet's membrane, is a very thin ($\frac{1}{2500}$ inch thick at the margin, and $\frac{1}{3500}$ thick at the centre), structureless, basement membrane, closely adherent to the posterior surface of the corneal tissue proper. It is very elastic, and, when peeled off from its attachment to the true cornea, rolls up with its attached surface innermost. It is quite brittle, so much so that it is sometimes fractured. At its margin it is continuous with the *ligamentum pectinatum iridis*. It resists most chemical agents, being the toughest layer of the cornea.

The *endothelial layer* (*e'*, Fig. 9), consists of a single layer of flattened, polygonal, nucleated cells lining the posterior surface of Descemet's membrane. They are of a similar character to the endothelial cells lining the serous cavities. Their function is to secrete a small portion of the aqueous humor.

NERVES.—The nerves going to supply the cornea, are derived chiefly from the two or three long ciliary nerves of the nasal

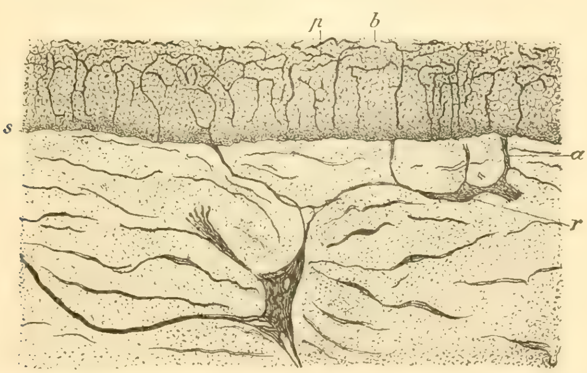

FIG. 10.—NERVE SUPPLY OF THE CORNEA, FROG'S. (After Landois and Stirling.) *r*, Nerve nucleus in substantia propria; *a*, fibre from it; *p* and *b*, termination of fibres in epithelial layer.

branch of the ophthalmic. Some branches are derived from the short ciliary nerves given off from the lenticular ganglion, and some branches from nerves supplying the conjunctiva—the lach-

rymal and infra-trochlear nerves. The ciliary branches pierce the sclera to enter the cornea, the conjunctival branches enter through the *limbus conjunctivæ.* Immediately upon entering the corneal tissue, the nerve branches—twenty-five to forty-five in number—lose their medullary sheaths (are therefore trans-

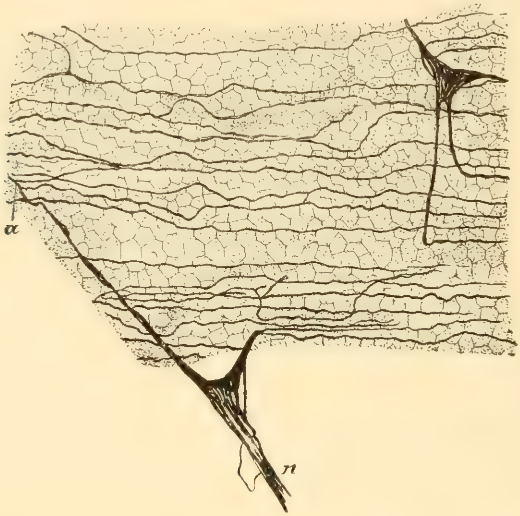

FIG. 11.—NERVE SUPPLY OF THE CORNEA, FROG'S. (After Landois and Stirling.) *n*, Nerve fibre and nucleus from which a second fibre, *a*, is given off.

parent) and arrange themselves into two networks in the corneal substance proper.

The denser network (*a*, Fig. 11) is formed just back of Bowman's membrane. From this numerous fine branches are given off, which pierce Bowman's membrane, to ramify in the epithelial layer and terminate in free endings, the exact nature of which has not as yet been proven. The second network, more delicate than the first, and with right-angled meshes, is situated just in front of Descemet's membrane. Branches from this supply the posterior layers of the cornea.

At the periphery of the cornea, in the anterior portion of the true corneal substance, there is a zone about $\frac{1}{20}$ inch wide, which contains loops of blood-vessels. These are capillaries from the episcleral branches of the anterior ciliary arteries, and a few from the arteries supplying the conjunctiva—lachrymal and infra-trochlear.

Arcus Senilis (*senile bow*, or Gerotoxon, γέρων, old man, and τόξον, bow).—The white ring at the periphery of the cornea, often seen in advanced life, is a condition of old age, or of poor vitality in middle life. It begins as a crescent at the upper and lower margins of the cornea, giving to it an ellipsoidal appearance, the long axis being horizontal. The ends of the crescents finally meet at the outer and inner borders of the cornea, when the circle is complete. The inner margin of the *arcus senilis* shades off gradually into the clear cornea, but the outer margin is clearly cut and well defined, leaving a narrow rim of clear cornea between it and the limbus conjunctivæ. In marked cases of arcus senilis, the limbus conjunctivæ sometimes has grayish white crescents above and below the cornea, which finally meet at the outer and inner margins, as do the crescents in the corneal tissue. The arcus senilis is situated at the periphery of the cornea, and in the layer of the true corneal tissue. In advanced stages, it may affect Descemet's membrane, even Bowman's, and the epithelial layer. It is due to a fatty degeneration of the loops of the blood-vessels at the periphery of the cornea, or to the deposition of colloid material (Fuchs).

Physiology.—The chief function of the cornea is to transmit and refract rays of light. Owing to the fact that the cornea separates a rarer medium, the air, from a denser medium, the aqueous humor, it exerts a greater refractive power on rays of light, than any single agent in the dioptric system of the eye, even greater than the crystalline lens. It is therefore the most active medium in the eye, in bringing rays of light to a focus on the retina, and hence its great importance in the estimation of the refraction.

THE ANATOMY OF THE SCLERA.

(σκληρός, *hard.*)

The sclera is a dense, white, fibrous membrane, which together with the cornea forms the complete outer tunic of the eyeball. The cornea forms the anterior one-sixth, and the sclera the posterior five-sixths of the tunic. The outer surface of the sclera, is smooth except where the recti and oblique muscles are attached. It is connected to the capsule of Tenon, by loose con-

nective tissue, and to the ocular conjunctiva in front by denser connective tissue. That portion of the sclera seen between the lids when open is popularly called "the white of the eye." The *inner surface* conforms to the outer surface of the choroid, and is joined to it and the ciliary body by a delicate connective tissue —*lamina fusca.*

The *thickness* of the sclera varies. It is thinnest anteriorly, near the corneal margin, $\frac{1}{60}$ inch, and thickest posteriorly near the optic nerve entrance, $\frac{1}{20}$ inch, where it is divided into several layers. The outer layers join the outer layers of the sheath of the optic nerve, which is derived from the dura mater; the middle layers join the inner layers of the sheath of the optic nerve, which are derived from the pia mater and arachnoid; the inner layers continue directly across the optic nerve entrance into the eye, but are perforated by many fine openings, forming the *lamina cribrosa.* Through these openings, the bundles of optic nerve fibres denuded of their medullary sheaths pass. At the same time; the fibrous tissue of the sclera forming the lamina cribrosa joins the sheaths (medullary) of these nerve fibres. The largest opening at the centre of the lamina cribrosa transmits the central retinal artery and is known as the *porus opticus.*

Histological Elements.—Fibrous connective tissue; elastic fibres; connective-tissue corpuscles; pigment cells.

Structure.—In structure the sclera is quite similar to that of the cornea. In fact they continue directly into each other, and differ essentially in but one particular, and that is, in the fibrous connective tissue going to make both structures. This tissue is opaque and white in the sclera, but quite transparent in the cornea.

The *connective-tissue bundles*, which in the cornea are transparent, flattened and laid down more or less regularly in lamellæ, are opaque in the sclera, not so much flattened, and run for the most part in two directions—longitudinally with the axis of the eye, and equatorially, or around the eye. Most of the fibres in the sclera run longitudinally. The circular fibres are most numerous near the inner surface of the sclera, and just back of the sclero-corneal junction, where they form a small band. This band-like appearance, is increased by the expansion of the tendinous insertions of the recti muscles at this zone of the sclera.

The *elastic fibres*, are between the fibrous connective-tissue bundles, and help to bind them together. From the inner surface of the sclera, they are prolonged into the lamina fusca, which attaches the sclera to the choroid.

The *connective-tissue corpuscles*, are flattened corpuscles corresponding to the branched corpuscles found in the cornea. They are situated in cell spaces between the fibrous bundles, and are sometimes stained by granular pigment.

The *pigment cells*, are of two kinds: *polyhedral branched cells* and *round cells*. They are most numerous near the inner surface of the sclera, and near the blood-vessels and nerves, where they penetrate it. Some eyes have an excessive pigmentation of the sclera, and in consequence have a dark, slaty color. Again, dark spots may be found on the sclera, anteriorly, in some eyes that are perfectly healthy. These spots are due to a collection of pigment cells at the points where the anterior ciliary veins pierce the sclera.

Blood-Vessels.—The blood supply to the sclera is from the ciliary system—the long, short, and anterior ciliary arteries. The *short ciliary arteries*, pierce the sclera near the optic nerve, and supply the choroid and ciliary processes, besides sending numerous branches to the scleral plexus behind (*posterior vascular zone*, or zone of Zinn) near the optic nerve entrance. From this zone, branches go to the optic nerve, and anastomose with branches of the central retinal artery is thus established. The only direct connection between the retinal and ciliary systems. The *long ciliary arteries*, two in number, usually pierce the sclera obliquely, near the optic nerve, run forward between the sclera and choroid, and supply the choroid and iris. In addition, they send many fine branches to the scleral plexus in front (anterior vascular zone).

The *anterior ciliary arteries*, are derived chiefly from the muscular arteries. They pierce the sclera just back of the cornea, and go chiefly to supply the iris and ciliary body, but, like the long ciliary arteries, they send many fine branches to the anterior ciliary zone.

The *anterior ciliary zone*, is a fine meshwork of vessels, situated on the anterior surface of the sclera, just back of the sclerocorneal junction. The anterior ciliary arteries furnish most of

the branches in this plexus, a few being derived from the long ciliary. This zone is plainly visible in inflammations of the uveal tract and the sclera. Branches from it, anastomose with conjunctival vessels. At the sclero-corneal junction, near the inner surface, is a venous sinus called *Schlemm's canal.* This canal is lined by endothelium and encloses a plexus of fine veins. It communicates with the anterior chamber, the anterior ciliary veins, and with veins from the sclera. Near the equator of the eye, the sclera is pierced obliquely by the *venæ verticosæ* from the choroid.

Anatomists are divided in opinion, as to whether nerves lying on the inner surface of the sclera, actually enter its structure.[1]

THE HUMORS OF THE EYE.

I.

AQUEOUS HUMOR.

The aqueous humor is a clear, slightly viscid, serous fluid filling the anterior chamber of the eye. It is composed chiefly of water (96.687 parts), a small amount of albumin (0.1223 part), together with sodium chloride (about 3.1907 parts), and a small amount of extractive matter. The entire weight of the aqueous is about 3½ to 5 grains. It is alkaline in reaction, has a specific gravity 1.0053, and a refractive index 1.3366. The aqueous humor is secreted by the blood-vessels of the iris and ciliary body, chiefly the latter, and is quickly reproduced when evacuated by a puncture of the cornea. It fills both portions of the anterior chamber of the eye. The *anterior chamber* is the space between the posterior surface of the cornea, and the anterior surface of the iris, and the central portion of the anterior capsule of the lens. The *posterior chamber*, is the space between the posterior surface of the iris near its periphery, and the anterior surface of the lens near its periphery, the zone of Zinn and the ciliary body.

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[1] Henle: "Handbuch d. Sinnes-Apporate," p. 599.

II.

VITREOUS HUMOR OR HYALOID BODY.

(*Vitreum, glass; ὕαλος, glass; εἶδος, like.*)

The vitreous humor, or *corpus vitreum*, is a transparent, gelatinous substance filling the interior of the eyeball back of the lens. It is surrounded by a very delicate, transparent, hyaloid membrane, which is closely attached to the retina, optic disc, and zone of Zinn. The vitreous body is concave in front for the reception of the posterior convex surface of the lens. The hyaloid membrane which surrounds the vitreous, is wanting in this cup (lenticular fossa) in front. At this point, it unites with the edge of the posterior capsule of the lens.

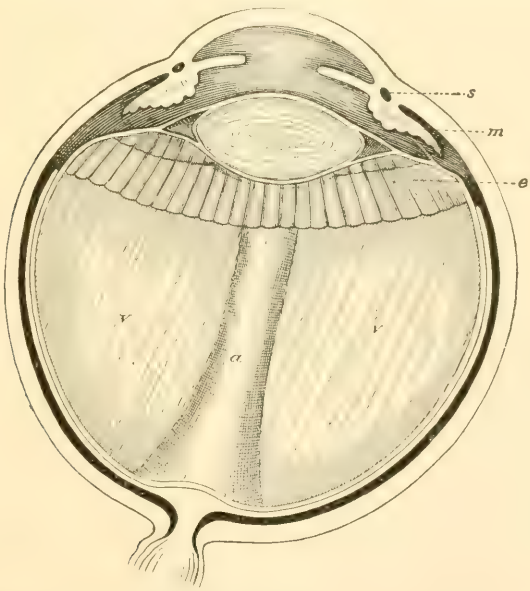

FIG. 12.—VERTICAL SECTION OF THE EYEBALL. (Schematic. H. T. Potter *del.*) *a*, Cloquet's canal; *e*, ciliary processes; *v*, vitreous; *s*, Schlemm's canal; *m*, ciliary body.

HISTOLOGICAL ELEMENTS.—Gelatinous matter; cells; nuclei; connective-tissue fibres (?); homogeneous structureless substance of the basement membrane.

STRUCTURE.—The exact structure of the vitreous is a matter still undecided. Histologists differ in their opinions as to its formation. Some claim it to be an entirely homogeneous structure

without any framework, while the greater number believe it to have a very delicate reticulum of cellular tissue, which supports the semi-fluid, gelatinous substance. Hannover (Germany, nineteenth century) has even claimed that membranes run through the vitreous, dividing it into segments, making a formation somewhat like that found in an orange. Stilling (Germany, nineteenth century) describes a cortical substance which seems to be formed into concentric layers, surrounding a nucleus that is situated a little forward of the centre of the vitreous. Various shaped cells and also nuclei, have been described as existing in the vitreous, especially in the cortical portion. These cells are abundant in fœtal life, but diminish very much after birth. They are of many shapes—round, oval, flat, and branched; some are nucleated, while others have a granular appearance. Extending through the centre of the vitreous from the optic papilla to the posterior pole of the lens, is a canal about $\frac{1}{25}$ to $\frac{2}{25}$ inch in diameter —*Cloquet's canal.* In fœtal life it contains the hyaloid artery; but after birth it is empty and is supposed to be a lymph-canal.

Nutrition.—The vitreous has no nerves or blood-vessels. It depends for its nutrition upon the lymph thrown out from the blood-vessels of the adjacent structures—upon the uvea principally, and the retina. The refractive index is 1.3366, the same as that of the aqueous humor. Owing to its cupped (concave) surface in front, the vitreous diverges rays of light. It thus acts as a negative or concave lens. Because of its dependence upon the uveal tract and retina for nutrition, any affection of these structures usually affects the vitreous indirectly. Hence the frequency of vitreous disturbances in association with diseases of the choroid and retina.

Physiology.—The chief function of the vitreous body is to maintain the shape of the eye, and to keep the contiguous structures in position, that is, the retina from becoming detached, and the lens from dislocation. The eye would of course collapse, were it not filled with a body like the vitreous humor.

Senile Changes.—Sometimes a fatty degeneration of the cells and reticulum of the vitreous takes place, which gives this humor a dirty or cloudy appearance. By the same means the vitreous becomes liquefied. The impaired sight of advanced life, is due in some measure to the former condition.

III.

THE CRYSTALLINE LENS.

The crystalline lens is a biconvex lens. It is disc-shaped, perfectly transparent and elastic. It is surrounded by a perfectly transparent capsule which is also very elastic. The lens in its capsule, is held in position by a suspensory ligament, the zone of Zinn. The most anterior and posterior portions of the lens are called its *poles*, anterior and posterior, while its periphery or edge is called the equator. The straight line joining the poles is called the *axis* of the lens. The average transverse diameter of the lens is $\frac{9}{25}$ of an inch, while the antero-posterior diameter, the axis, varies from $\frac{3}{25}$ to $\frac{5}{25}$ of an inch. The axis of the lens corresponds with the optic axis, or nearly so. However, the summit of the anterior surface of the lens may be as far as two degrees to the temporal side of the corneal axis (Helmholtz, Knapp), which axis practically coincides with the optic axis.

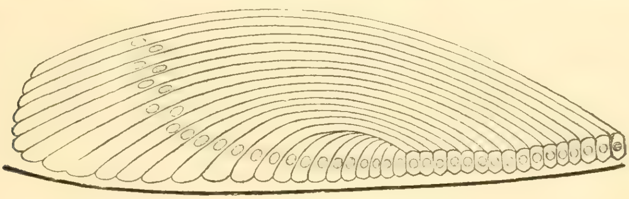

FIG. 13.—NUCLEAR ZONE OF THE LENS. (After Babuchin.)

The anterior surface of the lens is less curved than the posterior, and lies in contact with the posterior surface of the iris, except near its periphery. The posterior surface is more curved and lies in the cupped-out surface, hyaloid or lenticular fossa, of the front portion of the vitreous body. The radius of curvature of the anterior surface is $\frac{10}{25}$ of an inch, and of the posterior surface $\frac{6}{25}$ of an inch. The average refractive index is 1.4371 (Helmholtz). The whole weight of the lens is not more than four to five grains. It is composed of sixty parts of water; thirty-five parts of soluble, and two and a half parts of insoluble, albuminous matter; two parts of fat, with some cholesterin.

HISTOLOGICAL ELEMENTS.—*Lens proper:* lens fibres; amorphous cement substance.

Capsule: homogeneous, elastic substance; epithelial cells.

Zonule of Zinn: homogeneous, elastic fibres.

STRUCTURE.—The lens is composed of lens fibres arranged into concentric layers externally to form the *cortex*, which surrounds a central hardened mass, the *nucleus*. The cortex is soft and succulent, especially in young subjects, and is easily removed from the nucleus when the capsule of the lens is ruptured. The nucleus, although small in young subjects, is firm and not easily crushed between the fingers when removed from the eye. As age advances, the nucleus increases in density, the lens fibres lose part of their watery elements and become sclerosed, and at the same time assume a yellowish or brownish tint, especially in very old subjects. By oblique illumination, this enlarged and sclerosed nucleus, might be mistaken for an incipient

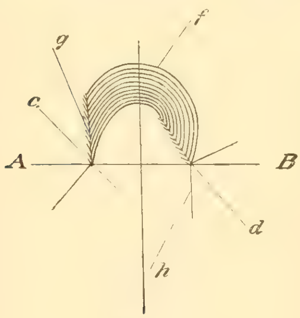

FIG. 14.

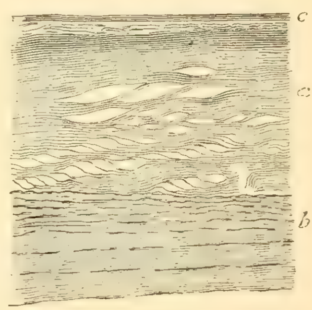

FIG. 15.

FIG. 14.—DIAGRAM SHOWING POSITION OF LENS FIBRES. (H. T. Potter *del.*) *A B*, Axis of lens; *c*, anterior pole; *d*, posterior pole; *g*, tail of inverted Y on anterior surface of the lens; *h*, tail of erect Y on the posterior surface of the lens; *f*, lens fibres.

FIG. 15.—SECTION OF CRYSTALLINE LENS FROM A HORSE. (H. T. Potter *del.*) *c*, Capsule; *a*, cortical fibres; *b*, nuclear fibres.

cataract by an inexperienced observer. Transmitted light with the ophthalmoscope quickly reveals the true condition of affairs. Both the cortex and the nucleus, are formed from lens fibres. These fibres have their origin in the epithelial cells lining the posterior surface of the anterior portion of the capsule. They are hexagonal in shape, those in the cortex having nuclei which are, for the most part, limited to a narrow zone of the lens near its equator, and have given to it the name nuclear zone (Fig. 13). The lens fibres are so arranged in the formation of the lens, that parts of each fibre lie on both surfaces of the lens; for example, a fibre beginning near the anterior pole of the lens extends to the equator, curves around it and extends a short

distance on the posterior surface; another fibre begins a little further from the anterior pole, extends parallel to the first, and is joined to it by its dentated edge, curves around the equator or edge of the lens, and ends a little further back on the posterior surface than did the first fibre. Fibre after fibre, is laid down in this way, until the posterior pole is reached (see Fig. 14). The beginning and ending of the fibres are along straight lines: these lines are present in each layer of the cortex. The layers are situated one directly above the other, down to the nucleus, and give to the lens an appearance as if divided by seams. There are usually three such seams on each surface of the lens, radiating from the poles to the periphery. Those on the front surface resemble the letter Y inverted (⅄), and those on the posterior surface the letter Y erect. Branching seams may be given off from these main seams. In incipient cataract, these seams often become opaque first, and when viewed by transmitted light with the ophthalmoscope, a star-shaped figure is seen.

Fig. 16.—Vertical Section of the Crystalline Lens from the Horse. (H. T. Potter *del.*)

The lens fibres forming the nucleus, are not so smooth as those entering into the structure of the cortex; being of earlier growth they are surrounded and pressed upon by the cortical fibres of more recent growth. They are shorter, firmer, not nucleated, and lie almost parallel to the axis of the lens, joined by dentated edges as in the cortex. The nucleus is quite dense and has a high index of refraction, 1.4541 (Krause, Germany, nineteenth century). It increases in density as age advances, the cortical layers of the lens also becoming firmer. Post-mortem changes, however, quickly liquefy the outer cortical layers, converting them into a cloudy white fluid—*liquor Morgagni* (Morgagni, eighteenth century).

Capsule of the Lens.—The capsule is a transparent, structureless membrane surrounding the lens. It is very flexible, and when ruptured rolls up with its outer surface inward. It is divided

into two portions, an anterior and a posterior. The anterior portion is thickest at the anterior pole ($\frac{1}{200}$ of an inch), and grows gradually thinner as it approaches the equator ($\frac{1}{6000}$ of an inch), and is thinnest at the posterior pole. On the posterior surface of the anterior portion is a single layer of polyhedral-shaped, epithelial cells containing round nuclei. They connect the posterior surface of the anterior portion of the capsule to the lens, become elongated toward the border of the capsule, and form nucleated lenticular fibres. By their continued formation in apposition to the lens fibres already present, they help to enlarge the lens, perhaps even after birth. It is claimed by one authority that

FIG. 17.

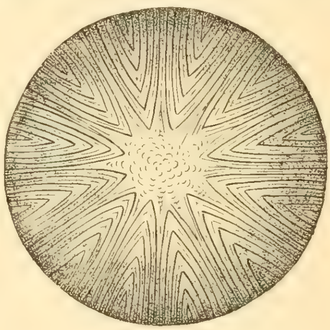

FIG. 18.

FIG. 17.—SIDE VIEW OF A CRYSTALLINE LENS FROM A NEW-BORN CHILD. (Arnold.) The anterior surface is turned to the left, the posterior surface to the right.

FIG. 18.—POSTERIOR VIEW OF A CRYSTALLINE LENS FROM AN ADULT. (Arnold.)

the lens increases in volume even to adult life (Priestly Smith, England, nineteenth century). There are no cells in the inner surface of the posterior portion of the capsule. The capsule is permeable, for through it the lens imbibes its nutrition from the uveal tract. It has no vessels or nerves. In the fœtus, the capsule is covered by a vascular network formed from the hyaloid artery, which network also helps to form the pupillary membrane present in fœtal life. Both begin to disappear in the last months of fœtal life, and at birth have, except in rare instances, entirely vanished.

The *zone of Zinn*, the suspensory ligament of the lens, *zonula ciliaris* (Zinn, Göttingen, 1755), is a transparent, elastic structure holding the lens in position. It is not a solid membrane, as most commonly described, but is a reticular structure composed of delicate, transparent connective-tissue fibres. These

fibres have their origin partly from the *ora serrata*, partly from the smooth portion of the inner surface of the *pars ciliaris retinæ*, chiefly from between the folds of the ciliary processes themselves. From this origin the most anterior fibres go directly to the front surface of the capsule (*z*, Fig. 19); the most posterior fibres go directly to the posterior surface of the capsule (*z'*, Fig. 19); while the intermediate fibres cross, those rising behind going to the front surface of the capsule, those rising in front going to the

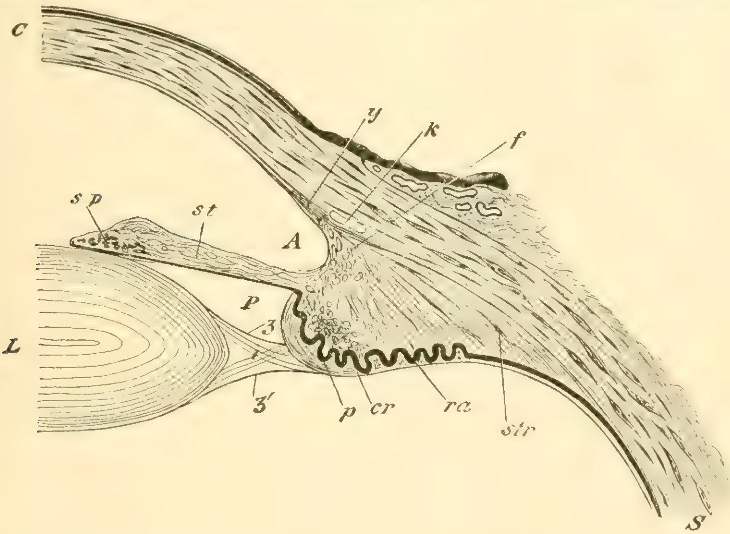

FIG. 19.—MERIDIONAL SECTION THROUGH THE ANTERIOR PORTION OF THE EYE. (H. T. Potter *del.*) *C*, Cornea; *S*, sclera; *L*, lens; *A*, angle of the anterior chamber; *P*, posterior portion of the anterior chamber; *str*, straight fibres of the ciliary muscle; *ra*, radiating fibres of the ciliary muscle; *cr*, circular fibres on the ciliary muscle; *z*, anterior fibres of the zonule of Zinn; *z'*, posterior fibres of the zonule of Zinn; *i*, Petit's canal; *f*, Fontana's spaces; *k*, Schlemm's canal; *y*, pectinate ligament; *sp*, sphincter fibres of iris; *st*, straight fibres of iris.

posterior surface of the capsule. The space—*canal of Petit* (Petit, Paris, eighteenth century)—between the most anterior and most posterior fibres of the zonule of Zinn and the periphery of the lens, is not an open space, but has intermediate fibres dividing it up into a number of small spaces, resembling somewhat the spaces of *Fontana* at the angle of the anterior chamber. The insertion of the fibres of the zonule of Zinn into the anterior capsule, is a little nearer to the anterior pole, than the insertion of the posterior fibres is to the posterior pole. The free portion of the zone of Zinn (*z* and *z'*, Fig. 19) forms part of the boundary of the posterior chamber, separating this chamber from the vitreous.

Physiology.—The function of the crystalline lens, is to assist in bringing rays of light to a focus on the retina. In consequence of its elasticity, and the action of the ciliary muscle, its refractive power is variable. It thus becomes more or less convex, according as near and far objects are to be clearly focused on the retina.

Senile Changes.—The lens fibres lose a large portion of their watery element, and both the cortex and the nucleus become denser in advanced life. The nucleus may even acquire a yellowish or brownish tint, while the whole lens becomes flatter and loses its elasticity. The changes in the lens fibres, may cause radiating opacities, and the hyaline substance is deposited upon the posterior surface of the anterior capsule. The zonule also becomes weakened, and thus dislocation of the lens is favored.

CHAPTER III.

THE UVEAL TRACT.

(*Uva, grapes.*)

Anatomy of the Uveal Tract.—Choroid.—Ciliary Body and Iris.—Function of Accommodation.

CHOROID, CILIARY BODY, AND IRIS.

THE uveal tract forms the second or middle tunic of the eye. It is composed of the *choroid*, *ciliary body*, and *iris*.

CHOROID.

(*χόριον, chorion,* and *εἶδος, like.*)

The choroid coat, is a thin and very vascular membrane, extending from the entrance of the optic nerve into the eye, forward between the sclera and retina to the *ora serrata*, where it joins the ciliary body. It forms the posterior seven-tenths of the middle tunic, while the ciliary body and iris form the anterior three-tenths. In thickness it varies from $\frac{1}{300}$ to $\frac{1}{150}$ of an inch. The choroid is loosely attached to the sclera, except near the entrance of the optic nerve, where it terminates in a narrow elastic ring formed of connective-tissue fibres, and is closely attached to the sclera at this point. A small number of elastic fibres extend from the posterior border (ring) of the choroid to the *lamina cribrosa* and to the neurilemma of the optic nerve.

HISTOLOGICAL ELEMENTS.—Connective-tissue fibres; elastic laminæ; involuntary muscle fibres (Müller); pigment cells, round and branched; lymph corpuscles; oval nucleated cells; endothelium; homogeneous intercellular substance; blood-vessels; nerves.

STRUCTURE.—The choroid is composed chiefly of blood-vessels, it and the ciliary processes being the most vascular structures of the eye. Its layers from without inward are:

(1) *Supra-choroidea*, or *lamina fusca.*

(2) *Tunica vasculosa*, composed of large and medium-sized vessels.

(3) *Membrana chorio-capillaris*, or *membrana Ruyschiana.*

(4) *Lamina vitrea*, or *membrana limitans.*

There is a uniform layer of pigmented cells lining the inner surface of the *lamina vitrea*, which was considered by most old authorities as belonging to the choroid. Later investigations teach us that this layer really belongs to the retina, as it is formed from the outer wall of the ocular vesicle. This layer will, therefore, be described with the retina.

The *supra-choroidea* or *lamina fusca*, joins the choroid to the sclera. It is composed of loose-meshed, cellular connective-tissue fibres, arranged more or less in lamellæ. Intermixed with the connective-tissue fibres, are numerous elastic fibres, pigment cells in great numbers, a few round, but most of them branched, the branches anastomosing, non-pigmented cells, free nuclei and lymph corpuscles. A homogeneous, structureless substance fills up the intercellular spaces and completes the structure. The posterior ciliary vessels and nerves, lie in this outer layer of the choroid. Between this outer layer of the choroid and the sclera is a space lined by endothelium, *peri-choroidal space.* It communicates by means of lymph-channels around the *venæ vorticosæ*, with the lymph-space in Tenon's capsule. Elsewhere it is a closed sac, being one of the lymph-spaces of the eye.

The *tunica vasculosa*, the next coat of the choroid, is composed mostly of blood-vessels, as its name indicates. The arteries are from the posterior ciliary—short and long. They lie internal to the veins, divide dichotomously, anastomosing freely, and finally empty into the capillary layer beneath—*membrana Ruyschiana.* The veins to this layer, which are more numerous and lie external to the arteries, are derived in a great measure from the capillary layer beneath, but receive many branches from the ciliary body and iris in front. These veins are collected into four to six groups, the veins in each group being directed toward a common centre near the equator of the eye. The smaller veins uniting as they go to form larger ones, finally unite in one large vein, which, from the peculiar arrangement of the veins forming it (the veins converging from all points to a centre or vortex), is called *vena vorticosa*, or collectively *venæ*

vorticosæ (2, 2, Fig. 20). These pierce the sclera very obliquely near the equator of the eye and empty into the ophthalmic vein. The vessels forming the tunica vasculosa lie in a loose stroma composed of branched cells, pigmented and non-pigmented, and a few involuntary muscular fibres (Müller). The pigmented cells are most numerous in the outer portion of the stroma, diminishing gradually toward the inner portion, and disappear entirely in the next or capillary layer of the choroid.

The *membrana chorio-capillaris*, consists of a very dense capillary network formed from the short posterior ciliary vessels (a

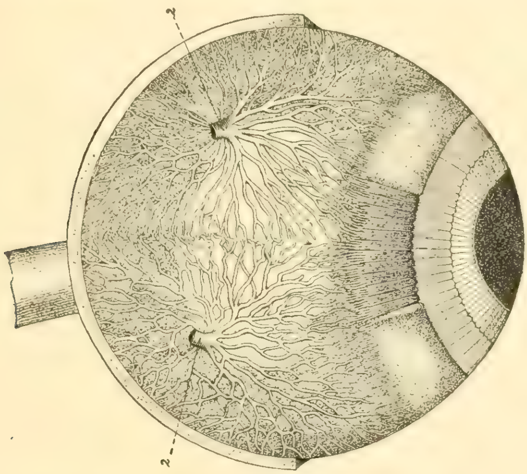

FIG. 20.—SCLERA REMOVED, SHOWING VENÆ VORTICOSÆ. (H. T. Potter *del.*) 2, 2, Venæ vorticosæ.

few recurrent branches from the long posterior ciliary vessels add to it anteriorly). In the intervening spaces, which are very narrow, is a homogeneous, structureless substance. This layer ends at the *ora serrata*, and contains no pigment cells.

The *lamina vitrea*, is the internal limiting membrane of the choroid, separating it from the retina. It is a very thin (about $\frac{1}{5000}$ inch thick), hyaline, structureless membrane, firmly attached to the capillary layer by its outer surface. Its inner surface is covered by a single layer of epithelial cells, deeply stained with pigment (the tapetum), which belongs to the retina.

PHYSIOLOGY.—The structure of the choroid being highly vascular, its chief function, together with the ciliary processes, is to supply nutrition to the structures lying adjacent—the lens,

vitreous, and outer layers of the retina, which are deficient entirely or partly of blood-vessels. The lymph thrown out by the choroidal and ciliary vessels, goes to supply the lens, entering this structure by means of lymph-channels (?), the anterior portion of the vitreous and the outer layers of the retina. The visual purple (Boll, *Rome*, Kuhne, *Heidelberg*, nineteenth century), which may or may not be necessary to vision (it being absent at the macula), is furnished in part by the choroid.

CILIARY BODY.

(*κύκλος, a circle.*)

The ciliary body, forms the middle zone of the uveal tract. By its position it serves to connect the posterior zone, the choroid, with the anterior zone, the iris. It is about $\frac{2}{10}$ of an inch wide antero-posteriorly, and is composed of the ciliary muscle and the ciliary processes. A vertical section of the eyeball (Fig. 21) antero-posteriorly, shows the ciliary body to be triangular in shape. The base of the triangle is directed forward. The iris has its origin from the centre of this. The apex is directed posteriorly, where it is joined to the choroid. The sides or surfaces of the triangle look outward and inward. The outer surface is composed of straight muscular fibres, and is separated from the sclera by the *lamina fusca*, while the inner surface is composed of the ciliary processes and lies in direct contact with the zonule of Zinn.

HISTOLOGICAL ELEMENTS.—(1) *Ciliary Muscle.*—Unstriated muscle fibres: connective-tissue fibres; blood-vessels; nerves.

(2) *Ciliary Processes.*—These contain elements similar to those found in the choroid, except capillaries, which they do not possess, the arteries passing directly into veins. In addition, they contains the elements of the *pars ciliaris retinæ*, which assist in the formation of the ciliary processes, namely: pigmented epithelial cells; non-pigmented cylindrical cells; homogeneous intercellular substance.

STRUCTURE.—(1) *Ciliary Muscle.*—This forms the outer portion of the ciliary body and is composed of longitudinal, radiating, and circular fibres of the non-striated variety. They have a common origin from the inner wall of Schlemm's canal, from a ten-

dinous ring at the junction of the cornea and sclera, from the ligamentum pectinatum, and from the sclerotic back of the sclero-corneal junction. From this origin the *longitudinal* fibres (*str*, Fig. 19), the most external, run directly backward to be inserted into the outer layers of the choroid, opposite the *ora serrata*. The *radiating* fibres (*ra*, Fig. 19) from almost a meridional direction externally, gradually but completely change the direction of their course as they go inward, until at their innermost and most anterior aspect they have an equatorial or circular course, giving origin to the *circular fibres* or circular muscle of Müller (*cr*, Fig. 19), the third and innermost portion of the ciliary muscle.

(2) *Ciliary Processes.*—These form the innermost portion of

FIG. 21.—MERIDIONAL SECTION THROUGH THE CILIARY REGION OF THE EYE. (H. T. Potter *del.*) *a*, Iris; *b*, pigment layer of the iris; *p*, ciliary processes; *r*, radiating fibres of the ciliary muscle; *e′*, longitudinal fibres of the ciliary muscle; *e*, large arterial circle of the iris; *a* and *c*, cross-section of ciliary veins and arteries where they pierce the sclera.

the ciliary body. They are a continuation of the choroid, except its capillary layer, and the retina, or *pars ciliaris retinæ*, from the *ora serrata* forward. The choroidal portion ends opposite the circular muscle of Müller, where it forms the anterior inner angle of the ciliary body. The retinal portion (*pars ciliaris retinæ*), together with the limiting membrane of the choroid, pass over into and form the posterior layer of the iris, that is, the limiting membrane and posterior pigment layer of the iris. The structure of the choroidal part of the ciliary processes is almost identical with that of the choroid. Like the

choroid, it has a delicate connective-tissue stroma deeply stained with branched pigment-cells giving to it a black color, whereas in the choroid the color is more of a brown. The ciliary processes are most abundantly supplied with blood-vessels, the arteries apparently emptying directly into small veins, no capillaries intervening. In this respect (having no capillaries) it differs in structure from the choroid. The next layer, the *limiting membrane* of the ciliary processes, is a direct continuation of the limiting membrane of the choroid—a homogeneous hyaline structure. The next two layers are furnished by the retina, being a continuation of that structure, as *pars ciliaris retinæ* from the *ora serrata* forward into the posterior surface of the iris (*b*, Fig. 21). The outer layer of the *pars ciliaris retinæ*, consists of a single layer of retinal pigment-epithelium, a direct continuation of the pigment layer (tapetum) of the retina. The inner layer of the *pars ciliaris retinæ*, consists of a single layer of cylindrical cells resting perpendicularly on the outer pigmented epithelial layer. The cylindrical cells are not pigmented. They are a direct continuation (as one layer of cells) of all the inner layers of the retina. Both the choroidal and retinal layers anteriorly are thrown into longitudinal or meridional folds, seventy to eighty in number, forming in this way, the anterior or folded part of the ciliary processes (*p*, Fig. 21). The posterior portion of the ciliary processes is not folded, but remains perfectly smooth.

PHYSIOLOGY.—The ciliary body performs a double function. The muscular portion is the agent of the accommodation of the eye for vision at different distances. The ciliary processes furnish nutrition to the lens, and the anterior portion of the vitreous, besides supplying a great part of the aqueous humor.

The changes which Helmholtz and others before him,[1] observed in the eye in accommodation for near objects are:

1. The pupil contracts.
2. The pupillary margin of the iris moves forward.
3. The peripheral portion of the iris recedes.
4. The anterior surface of the lens becomes more strongly curved, and its vertex advances.
5. The posterior surface of the lens becomes a little more

[1] "Optique Physiologique," translated by Javal and Klein, p. 142, Paris, 1867.

convex and does not change its position perceptibly. The lens becomes also thicker in the centre.[1]

Helmholtz adds that since the volume of the lens must remain the same, we may conclude that the oblique diameter of the lens must be shortened.

Helmholtz, as had others before him, argued from these facts that the changes in the lens were sufficient to explain the function of accommodation. Young[2] discovered the fact that the act of accommodation lay in the crystalline lens, but he mistakenly supposed that the lens was itself a muscle. Cramer and Helmholtz, propounded essentially the theories that are as yet accepted in regard to accommodation, although it must be confessed, that there is a difficulty in assuming that when the eye is in a state of rest, the zonule is in a state of tension. The lens, although not a muscle, is an elastic body kept stretched by its attachment to the annular ligament, as an elastic hoop would be flattened by the traction of two cords attached at two opposite points.[3]

MECHANISM OF ACCOMMODATION.

When the eye is in a state of rest the lens is adjusted to vision at an indefinite distance. It is supposed to be flattened by the tension of its suspensory ligament, the zonule of Zinn. It is this supposed tension of the suspensory ligament, when the eye is in a state of rest, that has thrown doubt upon the theory of accommodation as first plainly set forth by Helmholtz, and as now generally accepted. It is believed that when the ciliary muscle is in repose, the capsule compresses the lens, and thus increases its diameter and diminishes its convexity. The changes in its convexity, which make it able to focus rays from near objects, which are divergent, is brought about by the contraction of the ciliary muscle acting again upon the zonule, so that it is relaxed, and the lens allowed to enlarge in its capsule. Every one is conscious of an effort—or may make himself conscious of an effort—in looking at near objects, and if the effort be continued too long a sense of fatigue results. The function

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[1] Archiv für Ophthalmologie, B. I., Ab. ii., p. 63.

[2] Transactions Royal Society, London, 1793–1801.

[3] John Green: "Handbook Medical Science," vol. i., p. 4.

of accommodation may be illustrated by the simple experiment of looking through wire or other network at a distant object. When looking at the distant object, the wires are not seen, and when looking at a near one, the distant object is lost. This is conclusive evidence, as Young long ago showed, that a change must take place in the eye in changing from distant to near objects, or *vice versa.* When the ciliary muscle contracts, the choroid is drawn forward with, probably, a slightly spiral motion of the lens. The contents of the globe situated posteriorly to the lens, are compressed and the suspensory ligament is relaxed. The lens becomes more convex by virtue of its own elasticity when the compressing and flattening action of the suspensory ligament is diminished. After death, when the tension of the zonule is artificially diminished, the same thing occurs. The lens is more soft and more elastic in early life. Then the accommodative power is at its maximum. But it may be said that accommodation is a function which begins to become impaired at a very early age. Indeed, the ciliary muscle and the lens undergo changes from infancy onward.

Changes of the Iris in Accommodation.—The pupil becomes smaller in accommodating the eye for near objects, but the contraction of the pupil is not one of the essential conditions of accommodation. Cases have been known in which the iris was completely paralyzed, but the power of accommodation remained the same.[1]

Donders[2] has also shown that increased convergence of visual lines, without any change in the accommodation, causes the pupil to contract, and that when accommodation is affected without contractions of the visual axis, each stronger tension is combined with contraction of the pupil. Donders also states that by alternating accommodation for a remote and a near object, he could voluntarily contract and dilate the pupil more than thirty times in a minute. Brown-Séquard,[3] quoted by

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[1] Helmholtz: "Optique Physiologique," Paris, p. 151.

[2] "Anomalies of Accommodation and Refraction of the Eye." The New Sydenham Society, London, p. 574.

[3] Brown-Séquard: "Recherches expérimentales sur l'Influence excitatrice de la Lumière, du Froid et de la Chaleur sur l'Iris." Journal de la Physiologie, Paris, 1859, tome ii., 287, note.

Flint,[1] mentions a case in which the pupil could be contracted or dilated without changing the position of the eye, or making an effort of adaptation for a long or a short distance.

Accommodation in the Lensless Eye.—One of the best observed cases of this kind was fully described by the late Dr. Edward G. Loring.[2]

"The patient, a female, lost her glasses intended for near work while on board ship, and had to rely entirely on glasses intended for the distance. This pair had now become very much worn, and she simply wished to have them accurately measured, and a new pair made precisely like them. I found them to be convex, three and a half inch focus; and, with these glasses, vision was a little better than two-thirds of the normal standard.

"To my surprise, the patient then picked up a newspaper, and pushing this back and forth, as persons ordinarily do who are trying glasses, remarked that she could see perfectly well, quite as well, in fact, as with the old pair. This drew my attention more particularly to the case, and the result of a more critical examination was as follows: With $+\frac{1}{3\frac{1}{2}}$, the patient read with either eye fluently Snellen XXX., and was able, with both eyes, to pick out most of the letters of XX. at twenty feet. She could read No. X. at ten feet, and No. V. at five feet. With the same glass, and with no change of position on the nose, she read No. $1\frac{1}{2}$ Snellen fluently, holding the book naturally at twelve inches, which was about the distance at which she 'usually read.' The book was then gradually withdrawn, the patient reading aloud while this was done. It was found that twenty-one and a half inches was the greatest distance at which No. $1\frac{1}{2}$ Snellen could be read. She read No. I. Jaeger at twenty inches. The book was then advanced inch by inch, the patient reading aloud, till the book was within five inches of the eye. Inside of this, reading became impossible. These experiments were tried over and over again by myself, and were finally repeated in the presence of a brother oculist. This would give the patient an adaptability of the eye for different distances from twenty feet (or parallel rays) to five inches; or, in other words, an accommodation of $\frac{1}{5}$ $(A=\frac{1}{5})$, and a relative accommodation for the very finest print from twenty inches to five $(A=\frac{1}{6\frac{1}{2}})$. My own range, measured at the same time, was from

[1] "Physiology of Man," vol. v., p. 109.

[2] Flint, *loc. cit.*, p. 110.

twenty to five inches (vision being, in my left eye, exceptionally large, $\frac{20}{12}$).

"A careful examination of the pupils showed that they were of the normal size, as were the movements of the iris in every respect. With the ophthalmoscope, the pupillary space was found in the right eye to be entirely free from any remains of capsule, while in the left a narrow rim of the whitened membrane just encroached on the upper pupillary margin, but not to such a degree as to limit the size of the pupil, and thus to act as a diaphragm. The media of the eye were perfectly clear, and the ophthalmoscopic appearances were normal in every respect.

"The patient promised to return, for the purpose of having the reflections of the cornea measured by the optometer, and the facts determined by the ophthalmoscope, whether, under accommodative efforts, the eyeball became elongated. This she failed to do, and the case, as stated above, was shortly afterward reported to the New York Ophthalmological Society, April 12, 1869, and, in July, 1870, to the American Ophthalmological Society. In the index of the transactions of the American Ophthalmological Society for that year, it appears as a case of 'Apparent Accommodation in a Lensless Eye.' The paper, however, does not appear in the text, having been withdrawn at the last moment, as there were hopes that another examination could be obtained, and the cause of the accommodation of the eye be definitely settled.

"Two years later, Professor Förster published a series of similar cases[1] under the title of 'Accommodative Power in Aphakia.' The present case, however, differs from those reported by Förster, in the fact that the range of accommodation was $\frac{1}{12.8}$, larger than the maximum of any of his cases, and from the very important fact that whenever, in any of his cases, vision, both for the far and near, was taken, different glasses were used. In this case, the same glasses were used, worn in the same position, for all distances, from infinity up to five inches from the eye. So, too, in Woinow's[2] series of cases, the range of accommodation was taken only for the near, and amounted, on the average, to $\frac{1}{20}$.

"The only case which I know of that bears a close resemblance to the one above stated was reported by Arlt.[3] In this case, a young

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[1] Förster: "Accommodations-Vermögen bei Aphakie," Klinische Monatsblatter für Augenheilkunde, Erlangen, 1872, Bd. x., S. 39.

[2] Woinow: "Das Accommodations-Vermögen bei Aphakie," Archiv für Ophthalmologie," Berlin, 1873, Bd. xix., S. 107 *et seq.*

[3] Arlt: "Die Krankheiten des Auges," Prag, 1858, Bd. ii., S. 348.

man, with convex $\frac{1}{3\frac{1}{2}}$, could read both at six and at twenty-four inches, and could recognize the hands of a steeple-clock, at a distance of more than five hundred paces, with the same glass; but, as neither the size of the print nor that of the clock is given, no accurate conclusions can be drawn from the case.

"The case observed by me would then appear to be the first—as it is certainly the most remarkable—subjected to the recognized standard test of vision. Here the amount of accommodation was equal to that of a normal eye in a young person; and it would seem impossible that the ability to read the finest print at five inches, even taking into consideration the magnifying power of the glass, could be due to the overcoming of the circles of dispersion, as is claimed by the great majority of physiologists.

"Förster's views and the correctness of his tests have been objected to latterly by the following writers, cited by Woinow: viz., Donders, Mannhardt, Coert, and Abade.[1]

"Woinow, on the other hand, while he thinks that, in the normal eye, accommodation is performed solely by the lens, believes that some aphakial eyes acquire accommodative power, which is necessarily brought about through the agency of four factors; namely, the cornea, the vitreous, the action of the ciliary muscle and its effect on the bottom of the eye, and, finally, the effect of the external muscles of the globe. Woinow eliminates from this group the cornea, while Förster makes it the chief if not the sole agent. In two cases, Woinow was able to observe the reflections from the anterior surface of the vitreous humor, which, in the absence of the lens, was convex, as was shown by the image being upright. These reflections were too weak to be measured by the optometer; but they were seen to become smaller when efforts were made to see at close distances.

"It is to be regretted, and it certainly appears a little strange, that in neither Förster's nor Woinow's cases, was either the optometer or ophthalmoscope used in the elucidation of this problem. But, while Woinow's cases are, as he himself says, not conclusive, yet they seem, like Arlt's, Förster's, and the one just related, to substantiate the view that occasionally a considerable, if not a large degree of accommodation may exist, even in a lensless eye."

It is still denied on many sides that accommodation can exist on a lensless eye, but I have never been able to reconcile the

[1] Woinow: *Op. cit.*, Archiv für Augenheilkunde, Berlin, 1873, Bd. xix., S. 108.

denial with Loring's case, and with others that have been reported.[1]

It is interesting to note that a Scotch oculist, a pupil of Mackenzie, who practised in New York, William Clay Wallace, demonstrated the muscular character of the ciliary muscle, and suggested a theory of accommodation nearly correct, except that he attached too much importance to the ciliary processes, in 1836.[2] He thus anticipated Brücke and Bowman, who are usually said to have discovered the muscular character of the ciliary body independently in 1841.

Dr. Thomas Young's observations on vision, read before the Royal Society, May 30th, 1793,[3] are of the greatest interest. He starts out with the premise that the eye can, by the volition of the mind, be accommodated to view other objects at a much less distance than the farthest that it can see, but how this accommodation is effected, he says, has not yet been satisfactorily explained. He mentions the theories of accommodation of Kepler, Descartes, who with John Hunter thought the crystalline to be muscular; De La Hire, who maintained that the eye undergoes no change except the contraction and dilatation of the pupil; Pemberton, who also supposed the crystalline to contain muscular fibres, and Porterfield, who believed that the ciliary processes drew the crystalline forward, and made the cornea more convex. Other hypotheses are mentioned, and then he gives his own conclusions, based on the observation of Dr. Porterfield, who found that those who had been operated upon for cataract by depression of the lens no longer had the power of accommodating the eye to different distances, and he concludes that the rays of light coming from objects situated a small distance away, could only be brought to a focus on the retina, by a nearer approach of the crystalline to the spherical form, and he continues that he could imagine no other power capable of producing this change, than a muscle of a part or the whole of its capsule.

He then states, that examining the crystalline humor of an ox, turned out of its capsule, he discovered a structure which removed all the difficulties. He describes the lens of the ox as an orbicular, convex body, composed of a considerable number of transparent coats, and he thinks that each of these coats consists of six muscles attached to six tendons. His theory of the accommodation is, therefore, the

[1] David Webster: Archives of Pediatrics, vol. x., No. 11, p. 932, Nov., 1893.

[2] "The Structure of the Eye," New York, Wiley & Long, 1836.

[3] Transactions of the Royal Society of London for the year 1793, Part 2d, p. 169.

same as that of Mr. Hunter. But, as he puts it, "when the will is exerted to view an object at some distance, the influence of the mind is conveyed through the lenticular ganglion formed from branches of the third and fifth pair of nerves by the filaments perforating the sclerotica to the orbicularis ciliaris, and thence by the ciliary processes to the muscle of the crystalline, which, by the contraction of its fibres, becomes more convex, and collects the diverging rays to a focus on the retina." He continues that when he first observed the structure of the crystalline, he was not aware that its muscularity had ever been suspected, and he quotes Leeuwenhoek, who also had said that the fibres of the crystalline were muscular. Dr. Young's drawings of the appearance of the lens are nearly correct, even after the lapse of a hundred years, but his conclusions as to the nature of its transparent coats are manifestly wrong.

Anticipating Young, John Hunter[1] made the anatomy of the lens the subject of the Croonian Lecture, but he died before his observations were complete. The paper read was by his relative, Everard Home, who says that Mr. Hunter had an idea for many years that the crystalline humor was enabled by its own internal action to adjust itself so as to adapt the eye to different distances. Mr. Hunter examined the eye of the cuttle-fish, which he found composed of laminæ, whose appearance was evidently fibrous for some depth from the external surface, but becoming less and less distinct till at last this fibrous appearance was entirely lost. He concluded from this, that in the eye of the cuttle-fish the exterior parts of the humor are fibrous, the interior parts not, so that the central part is a nucleus round which the fibrous coverings are placed. Mr. Hunter began his experiments by the assumption that there ought to exist an analogy between this humor, if muscular, and others of a similar structure, which led him to expect that they would be acted upon by the same stimuli, and having found that a certain degree of heat applied through the medium of water, will excite muscular action after almost every other stimulus had failed, he applied this to the crystalline humor. The lens taken from animals recently killed, was immersed in water of different temperatures, and placed in such a manner as to form, by a proper apparatus, the image of a well-defined object, so that any change of the place of that image, from the stimulating effects of the warm water upon the humor, would be readily ascertained. Mr. Hunter had gone thus far with his experiments, but he did not make sufficient progress to enable him to draw any conclusions. He, however, writes to Sir Joseph Banks, claim-

[1] Transactions of the Royal Society of London, 1794, Part 1st, p. 21.

ing the discovery of the *crystalline humor* as being muscular. Mr. Hunter, in this letter, goes on to say, that there is a power in the eye by which it can adapt itself to different distances, far too extensive for the simple mechanism of the parts to effect. He then goes on to give the views of different writers on this subject of accommodation, and he adduces the fact that in many animals the shape of the eyes is unalterable, as in all of the whale tribe. The sclerotic coat is above one-half an inch thick, while in many fish this coat is composed of cartilage, and he says that in all birds the anterior part is, he believes, composed of bone.

From all these considerations, Mr. Hunter says, that he saw no power that could adapt the eye to the various distances of which we find it capable in the human body, unless we suppose the lens to be varied in figure, which can only be effected by a muscular action within itself. Here Mr. Hunter evidently assumed too much, but starting out with such a premise he came very easily to his incorrect conclusion, as he says, with this idea strongly impressed on his mind, finding that in many animals when the crystalline humor was coagulated, it had a fibrous structure like muscles, it seems to him to confirm his view, and, continuing, he attempts to get the proof. Knowing that in all violent deaths the muscles contract, he supposed the crystalline humor, if muscular, would show signs of this effect. For this purpose, he got the eyes of bullocks when removed from the sockets the moment the animal was knocked down, and while the eyes were warm the humors were removed. After making the notes up to this point, Mr. Hunter suddenly died. Mr. Home continues the subject by the statement that Leeuwenhoek had discovered a fibrous appearance in the crystalline lens, but he claims for Mr. Hunter that he discovered an eye, in which this structure of the lens was perfectly distinct. It is now unnecessary to say that Mr. Hunter's discovery was no discovery at all. With our better knowledge of anatomy, we have been able to demonstrate that Mr. Hunter's muscle, with its fibres, was of an entirely different substance—that there is no muscle whatever in the crystalline lens, but that its change in form is due to muscular force exerted upon it from without.

The second paper by Thomas Young was read before the Royal Society of London, on November 7th, 1800. Donders pays a high tribute to this great paper, as being one of the foundation-stones in the construction of his edifice. It was the Bakerian lecture on the mechanism of the eye.[1] He alludes in it to a paper published just

[1] Philosophical Transactions of the Royal Society of London for the year 1801, Part 1st, p. 23, where he says Mr. Hunter had anticipated him in his opinions.

one hundred years ago, of which mention has just been made. He is combating the hypothesis of the muscularity of the crystalline lens, as Everard Home, then dead, had also done, and he begins with some general remarks on the sense of vision, with certain dioptrical propositions founded on the works of Newton, and he presents an optometer. On measuring his own cornea he found the vertical diameter or chord to be $\frac{45}{100}$ of an inch, while the horizontal diameter or chord, was nearly $\frac{49}{100}$ and its radius $\frac{31}{100}$. He states that his own eye in a state of relaxation collects to a focus on the retina those rays which diverge vertically from an object of a distance of ten inches from the cornea, and the rays which diverge horizontally from an object at seven inches distance, for, as he says, "if I hold the plane of the optometer vertically, the images of the line appear to cross at ten inches, if horizontally, at seven inches." This was the discovery of astigmatism. He says he never experienced any inconvenience from this imperfection, nor did he discover it until he made these experiments. He observes, also, that a Mr. Cary informed him that he frequently had taken notice of a similar circumstance—that many persons were obliged to hold a concave glass obliquely in order to see distinctly, counterbalancing, by the inclination of the glass, the too great refractive power of the eye in the direction of that inclination. This is continued to this day, by certain near-sighted persons who thus correct their astigmatism, and prefer this kind of correction to the use of cylindrical glasses. Dr. Young continues that this difference is not in the cornea, for it exists when the influence of the cornea is removed. He ascribes his astigmatism to the obliquity of the uvea and of the crystalline lens, which is about ten degrees. Dr. Young determined the refractive power of the crystalline lens by an experiment suggested to him by Dr. Wollaston. He first found the refractive power of the centre of the human lens to that of water, to be as 21 to 20. But on the whole, he says, it is probable that the refractive power of the centre of the human lens, in its living state, is to that of water nearly as 18 to 17, and after death 21 to 20. Dr. Young continues to remark on the evidence of his astigmatism in saying: "When I look at a minute point, such as the image of a candle in a small concave speculum, it appears as a radiated star, as a cross, or as an unequal line, and never as a perfect point, unless I apply a concave lens inclined at a proper angle to correct the unequal refraction of my eye."

He continues with an experiment showing the different form of the images, as he brings the point nearer or removes it farther off. Dr. Young then goes on to say that the power of accommo-

dation of the eye to various distances appears to exist in very different degrees in different persons. He himself can see an object $\frac{29}{10}$ of an inch for vertical rays and $\frac{26}{10}$ of an inch for horizontal. He remarks that he has reason to believe that the faculty diminishes as persons advance in life. Dr. Young answered Mr. Porterfield's arguments for the power of accommodation without the presence of a lens, because he seems to think that if it could be proven that there was accommodation in aphakia, it was also shown that the lens took no part in accommodation. Dr. Young certainly proved that the accommodation does not depend on any change in the curvature of the cornea, or in any material alteration of the length of the eyeball, and he deduces from the fact of the aberrations of the lateral rays, a decisive argument in favor of a change in the figure of the crystalline lens. Certainly, his labors made an epoch which, though often alluded to, has never been fully recognized by all the writers. His paper was the first great step in the determination of the principal factor in accommodation, and the first description of astigmatism. As to the latter, it so happened that his investigations proved that he, himself, had an unusual form of that error. We now know that corneal astigmatism, with the greatest refraction in the vertical meridian, is far more common than lenticular astigmatism, or than corneal astigmatism with the greatest refraction in the horizontal meridian.

The *function of nutrition*, performed by the ciliary processes is accomplished through its very rich blood supply. The nutritious lymph thrown out from the ciliary processes, has only to penetrate the zone of Zinn, to be in direct contact with the lens capsule and the anterior portion of the vitreous. Through the aqueous humor it is also thought to help nourish the cornea, but only slightly.

Both of the above functions, accommodation and nutrition, of the ciliary body, are greatly facilitated by the mere fact of the *folded* condition of the ciliary processes, a fact that has not always received due attention. These folds are for a double purpose: First, to increase the blood supply in this region; second, to prevent the mechanical detachment of the retina.

First, as to the increased blood supply. These folds in the ciliary processes, like the sulci in the brain, increase its surface. As they are composed mostly of blood-vessels the blood supply to this region is increased two or three times by this folding or

plaiting process. This is a very important condition, since the lens has no blood-vessels, and must be supplied by the nutritious lymph thrown out from the ciliary processes. Therefore, the great necessity of a rich blood supply to them.

Second, the prevention of mechanical detachment of the retina. Were the ciliary processes not in plaits or folds, but laid down perfectly smooth on the inner surface of the circular muscle, at each contraction of this muscle they would be puckered into folds, as they must then necessarily occupy a less space during accommodation or contraction of the ciliary muscle.

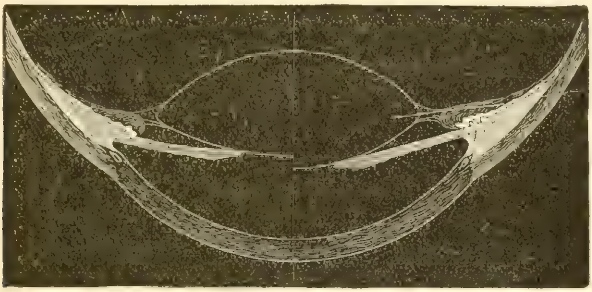

FIG. 22.—CHANGES IN THE LENS DURING ACCOMMODATION. (Adapted from Kramer, Arlt, Helmholtz, by Loring.[1]) The right hand of the diagram represents the eye in a state of rest. The left shows accommodation for near vision. The iris is shown as projected forward and contracted in accommodation. The ciliary processes do not touch the margin of the lens.

This puckering into folds, from a perfectly smooth condition would tend to, if it did not actually cause, a detachment at the base of each fold. Whereas, if, as is actually the case, the folds existed before the contraction of the muscle, they would only be pressed tighter together during the contraction, to relax again with relaxation of the muscle, and thus prevent, first, any tendency to separation of the processes from the muscle, and, second (as the processes are made up in part, by a continuation of the choroid and retina in a modified form over their inner surface), detachment of the choroid and retina.

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[1] "Text-Book of Ophthalmoscopy," Part I., p. 222.

III.

IRIS.

(*ἶρις, a rainbow.*)

The iris forms the third and anterior zone of the uveal tract. It is a thin membrane arising from the anterior and shortest side of the triangular ciliary body. A few fibres are also derived from the *ligamentum pectinatum iridis*, and from the inner wall of Schlemm's canal. From this origin it extends inward and a little forward, having a circular perforation, the pupil, a little to the nasal side of its centre. The *posterior surface* of the iris, except for the radiating lines from the pupil to the

FIG. 23. -PERSISTENT PUPILLARY MEMBRANE. (Agnew.[1])

periphery, is smooth. Near the pupillary margin it rests against the anterior capsule of the lens, while near the periphery it is free from the lens, thus leaving a space between the outer part of the posterior surface of the iris and the lens—the *posterior chamber*, or posterior part of anterior chamber (*P*, Fig. 19). The *anterior chamber* (anterior part of it) is the space between the posterior surface of the cornea, the anterior surface of the iris, and the central portion of the anterior capsule of the lens. When the pupil is widely dilated, these chambers communicate freely. The pupil constantly varies in size from muscular action, having a mean diameter of about four twenty-fifths of an inch.

[1] Transactions American Ophthalmological Society, vol. iii., p. 110.

Allowing four twenty-fifths of an inch as the mean diameter of the pupil, the mean width of the iris is about four twenty-fifths of an inch. In thickness the iris varies from one one-hundred-and-twenty-fifth to two one-hundred-and-twenty-fifths of an inch, being thickest near the pupillary margin.

The *anterior surface* of the iris is uneven, and has well defined tracings which are easily seen in the living eye, by oblique

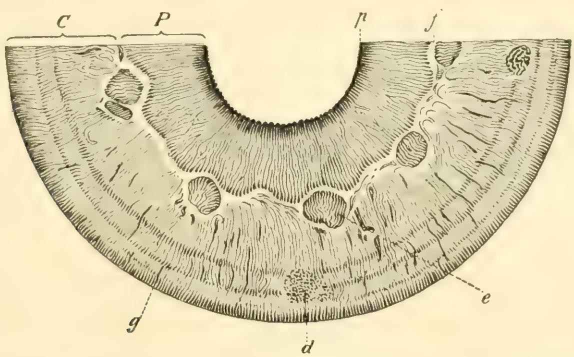

FIG. 24.—ANTERIOR SURFACE OF THE IRIS. (H. T. Potter *del.*) *C*, Ciliary zone; *P*, pupillary zone; *p*, fringe of pigment from posterior surface; *f*, smaller arterial circle; *e*, crypt; *g*, contraction furrows; *d*, pigment patch.

illumination. First, fine radiating lines are seen running from the periphery to the pupil. These are produced by the underlying blood-vessels in the stroma of the iris, which run from the periphery to the pupillary margin. Second, an uneven circular line (*f*, Fig. 24), about $\frac{1}{25}$ inch from and concentric with the pupil, divides the anterior surface into two zones, a pupillary zone (*P*, Fig. 24), lying to the inner side of the line, and a *ciliary* zone (*C*, Fig. 24), lying to the outer or peripheral side of the line. This circular line is produced by the lesser arterial circle of the iris. The radiating lines in the pupillary zone, are much finer than those in the ciliary zone, because the radiating vessels given off from the lesser arterial circle are much smaller than those given off from the larger circle. The pupillary zone is also at times differently colored from the ciliary zone. In the ciliary zone, near the circular line, are seen some facets (*e*, Fig. 24) dipping down into the stroma of the iris; and further peripherally in the same zone are often seen, especially in dark colored irides, five to seven concentric furrows (*g*, Fig. 24). All

of these markings on the anterior surface of the iris, are distinctly seen by oblique illumination, and should be studied in the healthy eye, if a correct diagnosis is to be made in the different diseased conditions of the iris, where they may be greatly changed in appearance.

HISTOLOGICAL ELEMENTS.—Connective-tissue fibres; elastic fibres (from ligamentum pectinatum iridis, and in the posterior limiting membrane); non-striated muscle-fibre; nuclear cells; pigment cells, branched and round; endothelium; amorphous intercellular substance; blood-vessels; nerves.

STRUCTURE.—The elements just named enter into the formation of the following layers which go to make the iris:

1. *Endothelial layer.*
2. *Stroma*, or *vascular layer* of the iris.
3. *Muscle-fibre layer.*
4. *Posterior limiting membrane.*
5. *Pigment layer.*

The *endothelial layer*, is a direct continuation to the anterior surface of the iris, of the endothelial cells lining the posterior surface of Descemet's membrane. This layer extends to the pupillary margin, and conforms to the anterior surface of the stroma, except at the facets (*e*, Fig. 24) in the ciliary zone of the iris, where it is wanting. These endothelial cells are not pigmented, except in very dark-colored eyes, when some of them contain pigment granules.

The *stroma* or *vascular layer*, is composed of connective tissue, branched and round cells and blood-vessels. The connective-tissue fibres, are striated in appearance and are woven together loosely and irregularly, having more of a circular course near the pupil, but a radiating direction near the periphery of the iris. The cells of the stroma are, for the most part, stellate with numerous branches joining one another, to form a delicate reticular structure. Intermixed with these branched cells, are some round cells. In dark-colored irides, both the branched and pigment cells, have pigment-granules in them which are absent in blue eyes and albinos. The blood-vessels, which are very numerous in the iris, are derived from the larger arterial circle at the base of the iris, and run in a radiating direction in the stroma toward the pupil. Near the pupil these vessels form a

second or lesser arterial circle, from which very fine radiating arteries are given off, which extend to the edge of the pupil to empty into veins. The arteries, lie nearer the anterior surface of the stroma, while the veins, lie nearer the posterior surface. It is to these blood-vessels covered by the stroma, that the radiating lines, seen by oblique illumination in the anterior surface of the iris, are due.

The *muscle-fibre layer* is imperfect. The muscle-fibres are of the non-striated variety, and are collected into a narrow band (*sp*, Fig. 16) in the posterior portion of the stroma, near the margin of the pupil. This narrow circular band, *sphincter pupillæ*, is the active agent in closing the pupil. The existence of radiating muscular fibres, *dilator pupillæ*, is doubtful. The dilatation of the pupil is brought about by the elastic action of the next layer of the iris.

The *limiting membrane*, which has its origin at the periphery of the iris and extends to the margin of the pupil, is a hyaline membrane, possessing elasticity and perhaps contractility, to which latter quality the dilatation of the pupil is now thought to be due. The *pigment layer*, is a continuation of the *pars ciliaris retinæ* on to the posterior surface of the iris. It extends to the margin of the pupil, where it can be seen as a black fringe (*p*, Fig. 24). This black fringe to the pupil, is especially noticeable when the pupil is contracted, or when a cataract is present, the white background of the cataract sharply contrasting with the black fringe of the pupil. Two layers of cells go to form the pigment layer. Embryology shows, that the inner layer is the direct continuation of the pigment-layer or tapetum of the retina, and that the posterior layer, is a continuation of the inner layers of the retina condensed into one layer of cells. Both layers of cells, except in albinotic eyes, are filled with granular pigment.

The *suspensory ligament* of the iris, or *ligamentum pectinatum iridis*, is derived from Descemet's membrane, and consists of fine, elastic fibres, so arranged as to form a delicate reticular structure filling up the angle between the periphery of the cornea and the iris. From this reticular structure, the elastic fibres are continued into the front surface of the iris, some of its fibres also into the anterior portions of the ciliary body, choroid, and

sclera. When the iris is torn from the sclera and ciliary body, in some of the lower animals these elastic fibres project out somewhat like the teeth in a comb; hence the name, *ligamentum pectinatum iridis*. In the reticular structure itself, at the angle of the anterior chamber, are found numerous spaces or sinuses, *the spaces of Fontana*, or Fontana's canal (Fontana, eighteenth century), which, in many of the lower animals, are quite well developed. These spaces, as well as the elastic fibres forming this ligament, are lined by the endothelium which passes over from the posterior surface of Descemet's membrane. The ligament, in fact, furnishes a bridge or continuity of issue for the endothelial layer on the posterior surface of the cornea, to pass over to the anterior surface of the iris. The *outer* fibres of the ligamentum pectinatum form the inner wall of Schlemm's canal, and the spaces (Fontana's) in this ligament communicate freely with the canal of Schlemm. The *posterior* fibres lie in direct contact with the anterior surface of the ciliary body, making it easy again for Fontana's spaces, and, through these, for the anterior chamber to communicate directly with the ciliary body. The *inner* fibres of the ligamentum pectinatum, form the outer boundary of the anterior chamber, at the angle between the periphery of the cornea and the iris.

The *color* of the iris, as blue, gray, pink, brown, or black, depends upon the amount of pigment the structure contains. Pigment is present, except in albinos, in the posterior or pigment layer of the iris. If there is no pigment present in the branched stroma-cells in front, the posterior pigment layer, though perfectly black, is seen through the stroma (by interference phenomena) as blue; or, if the stroma is very thick, as gray. When the stroma-cells also contain pigment, the iris appears brown, or, if they contain a great deal of pigment, black. In albinos, the iris contains very little if any pigment, and in consequence appears pinkish in color. In infants the almost universal color of the iris is blue.

The *pupillary membrane*, or part of it, may remain after birth. This is a delicate, semi-transparent, vascular membrane filling up the pupil during fœtal life. It consists of a looped meshwork of blood-vessels coming from the anterior surface of the iris, and of vessels that cover the capsule of the lens during

fœtal life.[1] Between the seventh and eighth months of fœtal life, the vessels begin to be absorbed at the centre of the pupil, and, at birth, as a usual thing, have disappeared altogether.

PHYSIOLOGY.—The iris aids in the act of vision: First, by controlling the amount of light allowed to go into the eye; second, by cutting off the marginal or oblique rays of light.

First, as to the *quantity* of light going into the eye. In a very strong light the pupil contracts, thus preventing too much light from entering the eye and dazzling it. On the other hand, in a very weak light, the pupil dilates to admit as much light as necessary to form a clear retinal image. The iris, with its central perforation—the pupil—is a self-adjusting diaphragm. It is, therefore, regulated by the intensity of the light coming upon the retina (the pupil acting reflexly through the retina). It also acts in association with accommodation and convergence, and also reflexly through the sympathetic nerve.

Second, the iris aids in vision by cutting off the marginal rays of light. The oblique or marginal rays of light, passing through the periphery of the cornea would, if unobstructed by the iris, also pass through the margin of the lens, come to a focus quicker than those rays of light passing through the centre of the lens, and thus form diffusion circles[2] on the retina, with consequent blurring of the retinal images. Again, by cutting off these marginal rays, the iris prevents chromatic aberration, a color phenomenon produced by rays of light passing through the extreme edge of a lens. The iris thus increases acuity of vision by rendering the lens of the eye achromatic.

The *movements* or *reaction* of the iris, are of two kinds—*reflex* and *associated*. They are controlled by the oculo-motor or third nerve, and by a branch from the cervical sympathetic. The oculo-motor nerve through the lenticular ganglion, supplies the sphincter muscle of the iris, and causes the pupil to contract when it is stimulated either directly or reflexly. The pupil becomes dilated and fixed, when this nerve is paralyzed. The sympathetic branch to the lenticular ganglion, is derived from the cervical sympathetic. It supplies the posterior limiting

[1] See Fig. 23.

[2] Diffusion circles are produced by rays of light coming to a focus before they reach the retina, and crossing, as in myopia; or in not coming to a focus at all, as in hypermetropia. See Myopia and Hypermetropia.

membrane of the iris, and through that membrane, produces dilatation of the pupil when it is stimulated. If the sympathetic branch is paralyzed, it allows the pupil to contract.

The *reflex reaction* of the pupil, is brought about either by the action of light directly in the eye, or by sensory stimuli applied to any portion of the body. Light always causes contraction of the pupil, sensory stimuli always produce dilatation of the pupil. Moreover, light always affects both eyes in the same way and at the same time, and this even though the light is thrown into only one eye. For example, light thrown into the left eye stimulates the left retina, which stimulus is transmitted along the left optic nerve to the chiasm, and from the chiasm along both optic tracts to the nuclear centres, back along the third nerves to *both* eyes, left and right, the pupils in both eyes reacting to the same extent and at the same time—*consensual* or *consentaneous reaction.*

Sensory stimuli, act on the eye through the cervical sympathetic, and as this supplies the dilating fibres of the iris, the reason for the pupil always dilating under sensory stimuli, is clearly seen.

The *associated reaction* of the pupil: During both the acts of accommodation and of convergence, the pupil always reacts by contracting. This constant reaction of the pupil at the same time with the acts of accommodation and convergence, is termed the associated reaction of the pupil. This associated or consentaneous action of the pupil with the ciliary muscle (the agent of accommodation), and the internal recti muscles (agents of convergence), is due to the simultaneous excitation of the centres controlling these different functions. Since the sphincter of the iris, the ciliary muscle, and the internal recti muscles, are all supplied with motor force through the third nerve, and furthermore, since the centres of accommodation, of convergence, and of pupillary reaction are situated very closely together in a common nuclear centre in the brain, the associated or consentaneous action of all three, may be easily brought about. However, a stimulus may go to one of these centres, and not to the other two. For instance, the pupillary centre, may receive a reflex stimulus and cause reaction of the pupil when neither accommodation nor convergence is taking place. There may, there-

fore, be reaction of the pupil, and it is often seen without having accommodation or convergence, but—and this is to be noted—we never have normal convergence or accommodation, without reaction of the pupil. Bearing this fact in mind, that there may be reaction of the pupil without convergence or accommodation, but never accommodation or convergence without reaction of the pupil, it might indicate that the *associated reaction* of the pupil, depended upon a secondary stimulus—the desire to accommodate or converge—since it always occurs when either accommodation or convergence takes place, rather than upon a common stimulus primary to all three centres. This is, however, a debatable point.

BLOOD SUPPLY OF THE UVEA—CHOROID, CILIARY BODY, AND IRIS.—The *arterial* blood for the nourishment of the uvea, and indirectly through the uvea, for the nourishment of the lens, vitreous, and portions of the retina, is derived from the ciliary arteries—the posterior long and short, and the anterior.

The *short posterior ciliary arteries* (*a a*, Fig. 25), fifteen to twenty in number, pierce the sclera perpendicularly near the optic nerve, run forward, and enter into the formation of the *tunica vasculosa* of the choroid. They extend as far forward as the ora serrata, where they receive a few branches of communication from the anterior and the long posterior ciliary arteries. These arteries finally empty their blood into the capillary layer of the choroid—the *membrana chorio-capillaris.*

The *long posterior ciliary arteries* (*b*, Fig. 25), two in number, pierce the sclera obliquely near the optic nerve, one on the inner, the other on the outer side, and run forward between sclera and choroid to the ciliary muscle. In the anterior portion of the ciliary muscle, near the base of the iris, they each divide into two branches, which run in opposite directions concentrically around the base of the iris, to meet the branches from the opposite side, thus forming a complete arterial circle at the base of the iris—*circulus arteriosus iridis major* (*p*, Fig. 25). From this arterial circle, branches are given off which run in a radiating direction in the stroma of the iris from its periphery to near the pupil. Near the pupil, branches are given off at right angles to the radiating branches to form a second and lesser arterial circle—*circulus arteriosus iridis minor.* From this

smaller circle very fine radiating branches are given off, which extend to the edge of the pupil, and perhaps pass directly into small veins.

The anterior ciliary arteries (c, Fig. 25), usually four to six in number, are derived from the muscular branches of the ophthalmic which supply the recti muscles. They pierce the tendons of these muscles at their insertions and divide into a number of branches which ramify in the episcleral tissue near the margin

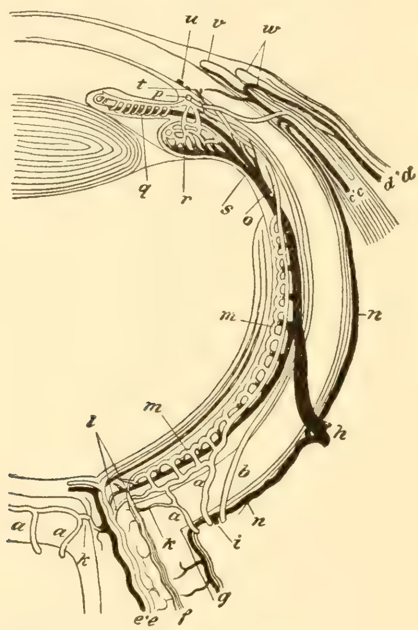

FIG. 25.—BLOOD-VESSELS OF THE EYE. (Schematic. After Leber.) 1. Conjunctival vessels: *d* and *d'*, posterior conjunctival; *w*, anterior conjunctival; *v*, loops in limbus conjunctivæ. 2. Uveal vessels: *a a*, posterior short ciliary; *b*, posterior long ciliary; *e* and *e'*, anterior ciliary; *p*, larger arterial circle of the iris; *q*, arteries of the iris; *m m*, capillary layer from posterior ciliary arteries; *r*, arterioles in ciliary body; *o*, arteriole from choroidal plexus going forward to anterior ciliary artery; *k*, *k*, arterioles from short posterior ciliary arteries penetrating the optic nerve and anastomosing with the retinal system of vessels; *s* and *n*, veins converging to *h*, vena vorticosa. 3. Retinal vessels: *e*, central artery; *e'*, central vein; *l*, arterioles from the central artery anastomosing with the uveal system of vessels; *u*, Schlemm's canal.

of the cornea. Some of these branches, anastomose with the conjunctival vessels, some pierce the sclera and help form the great arterial circle of the iris, situated in the anterior part of the ciliary muscle, while others pierce the sclera, and go to form an arterial circle situated further back in the ciliary muscle.

From the great arterial circle of the iris, as we have just

seen, the radiating vessels that supply the iris were given off. This great arterial circle also furnishes: (a) branches to the ciliary muscle, in the substance of which they break up and are lost in a delicate capillary network; (b) branches which pierce the ciliary muscle and go to supply the ciliary processes, anastomose freely in this structure, and at the free margins of the processes pass directly into veins; (c) and recurrent branches for the supply of the anterior portions of the choroid, where they anastomose with branches from the short posterior ciliary arteries, and are finally lost in the anterior portion of the capillary layer of the choroid.

The *venous blood* is returned from the uvea by an arrangement of the veins quite different from that of the arteries. The veins do not correspond to the arteries at all, except to the anterior ciliary, and even here there is not always a corresponding vein.

The blood from the *capillary layer of the choroid*, is collected into a network of very fine veins, this network becoming coarser and coarser by the smaller veins uniting to form larger ones, which veins in the vascular layer of the choroid, lie to the outer side of the arteries. The larger veins of the vascular layer of the choroid, are arranged into from four to six conical groups; the veins of each group converge from all directions toward a common centre, the summit of the cone, situated near the equator of the eye. At the summit of the cones the veins of each group join to form one large vein (*h*, Fig. 25, and 2, Fig. 20). There are four to six in all of them, which, from the peculiar arrangement of the smaller veins extending from all directions to a common centre or vortex, has gained for them the name *venæ vorticosæ*. They pierce the sclera very obliquely to empty into the ophthalmic veins further back in the orbit.

The veins from the *ciliary processes*, are derived directly from the arteries to this structure, no capillaries intervening. They pass backward to the vascular layer of the choroid, and assist from in front to form the venæ vorticosæ.

Nearly all the veins from the *ciliary muscle*, pass backward, anastomosing as they go with the veins from the ciliary processes, and empty their blood into the venæ vorticosæ. Finally, the veins from the anterior zone of the uvea, the iris, pass backward and empty their blood into the venæ vorticosæ.

From the above description, it is seen that most of the venous blood from the uveal tract is emptied into the venæ vorticosæ, and that it leaves the eye by this channel. Some of the veins from the ciliary muscle, however, do not empty into the venæ vorticosæ, but pierce the sclera anteriorly and ramify in the episcleral tissue corresponding to the anterior ciliary arteries. These veins communicate with Schlemm's canal, and with the conjunctival veins. They are the violet or purple colored veins, seen in the episcleral tissue just back of the cornea, in deep inflammations of the eye. This is the second route for the blood to escape from the eye. When from any cause, the circulation through the venæ vorticosæ is retarded, this anterior route is utilized for carrying off an extra amount of venous blood.

Nerves to the Uvea.—The nerve supply to the uvea, is derived from the third, the ophthalmic division of the fifth, and from the cervical sympathetic nerves, all of which act through the long and short ciliary nerves, given off from the lenticular ganglion. The lenticular ganglion, lies in a mass of fat at the posterior portion of the orbit, just to the outer side of the optic nerve and between it and the externus rectus muscle. It is a small, flattened, somewhat oblong ganglion, reddish-gray in color. It has three roots which enter it posteriorly: one from the nasal nerve (branch of the ophthalmic), a *sensory* root; one from the third nerve, a *motor* root; and one from the cervical sympathetic through the cavernous plexus. The branches given off from this ganglion are:

(1) The *short ciliary nerves*, twelve to fifteen in number. They pierce the sclera near the optic nerve, and run forward between the sclera and choroid in the lamina fusca to the ciliary body. In their course, they give off branches to form a fine meshwork in the stroma of the choroid. Anteriorly, they anastomose with branches from the long ciliary nerves.

(2) The *long ciliary nerves*, two to three in number, are derived from the nasal branch of the ophthalmic. They pierce the sclera obliquely a little in front of the short ciliary nerves, and run between the sclera and choroid, in the lamina fusca to the ciliary muscle, where they break up into a meshwork from which the ciliary processes and iris are supplied. The exact mode of the termination of the nerves in the iris, is not known.

CHAPTER IV.

Anatomy of the Retina, the Optic Nerves, and Orbits.—General Physiology of the Eye.

ANATOMY OF THE RETINA.

(*Rete, a net.*)

THE retina forms the inner tunic of the eye. It extends from the optic nerve entrance, between the vitreous and the choroid, to the beginning of the ciliary body, where all of its nervous elements end in a ragged or serrated border—*ora serrata*. The *tapetum* (*carpet*), pigment layer of the retina, however, together with its connective-tissue elements, reduced to a single layer of epithelial cells, do not stop at the ora serrata, but continue on the inner surface of the ciliary body, as *pars ciliaris retinæ*, and to the posterior surface of the iris up to its pupillary margin, as its pigment layer. The retina, therefore, really extends from the optic disc to the margin of the pupil, intact to the ora serrata, but in a modified form from the ora serrata to the margin of the pupil. The retina is thickest posteriorly near the optic disc ($\frac{1}{75}$ inch thick), and gradually grows thinner as it goes forward until near the ora serrata it is only $\frac{1}{200}$ inch in thickness. In the living subject, the retina is very nearly perfectly transparent, having a whitish-gray, filmy appearance, when viewed by the ophthalmoscope.

HISTOLOGICAL ELEMENTS.—NERVE ELEMENTS: nerve fibres; nucleated ganglion-cells; oval, nucleated nerve-cells; rods and cones; granular matter.

CONNECTIVE-TISSUE ELEMENTS: fibrous cellular fibres; oval nucleated cells; homogeneous cement substance; besides the *tapetum*, which is composed of epithelial cells containing pigment granules, the cells being held together by a homogeneous cement substance.

STRUCTURE.—The nervous matter in the retina resembles that in the brain (neuroglia), but the nervous elements appear

different elements in the different layers of the retina. The connective-tissue elements are found in all the layers of the retina, except the layer of rods and cones and the pigment layer.

Ten layers enter into the structure of the retina. From within outward they are:

1. *Internal limiting membrane.*
2. *Layer of optic nerve fibres.*
3. *Layer of ganglion-cells.*
4. *Internal molecular layer.*
5. *Internal nuclear layer.*
6. *External molecular layer.*
7. *External nuclear layer.*
8. *External limiting membrane.*
9. *Layer of rods and cones, or Jacob's membrane.*
10. *Pigment layer; tapetum.*

DESCRIPTION OF THE VARIOUS LAYERS.

The most internal layer of the retina (1, Fig. 26) is formed from connective-tissue elements, and will be described when that portion of the retina, is considered a little further on.

The *layer of nerve-fibre* (2, Fig. 26) is composed of nerve fibres continued directly from the optic nerve. These nerve fibres in the retina are analogous to the pale nerve fibres of the brain, and are transparent, as they are deprived of their medullary sheaths in passing through the cribriform fascia. The medullary sheath, sometimes remains on the nerve fibres after they enter the retina, when the characteristic "opaque nerve fibres" can be seen with the ophthalmoscope. The nerve fibres radiate in all directions from the optic nerve entrance. Near the entrance they are arranged into small bundles, but separate as they advance, and may be seen at times to form plexuses (Michel). This layer is thickest near the optic nerve entrance ($\frac{1}{125}$ inch), and grows thinner as it advances, finally to disappear at the ora serrata.

The *layer of ganglion-cells* (3, Fig. 26) is composed of a single layer of ganglion-cells containing nuclei and nucleoli, surrounded by a cloudy, granular substance. These cells are flattened and are somewhat oblong, the longer axis being perpendicular to the

surface of the retina. To the inner extremity of each cell a single nerve fibre, from the nerve-fibre layer, is attached. From the outer extremity of each ganglion-cell, two or three processes are given off, which pierce the internal molecular layer and are connected with its stroma, perhaps penetrating to the next layer (internal nuclear), to connect with the nerve cells of that layer. The ganglion-cell layer is about $\frac{3}{5000}$ of an inch thick.

The *internal molecular layer* (4, Fig. 26) is about $\frac{1}{1200}$ of an inch thick. It is composed of the most delicate nerve fibrils and connective-tissue network, together with granular matter of an unknown nature. The distal processes from the ganglion-cells, just described, and the proximal processes from the nerve cells in the next (internal nuclear) layer, enter this layer and perhaps communicate in it.

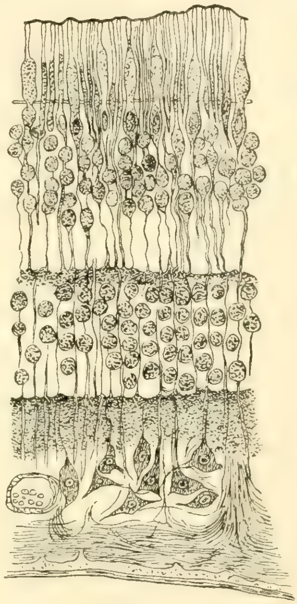

FIG. 26.—VERTICAL SECTION OF THE RETINA. (Schematic. After Landois and Stirling.) 1, Internal limiting membrane; 2, layer of optic nerve fibres; 3, layer of ganglion cells; 4, internal molecular layer; 5, internal nuclear layer; 6, external molecular layer; 7, external nuclear layer; 8, external limiting membrane; 9, layer of rods and cones, or Jacob's membrane; 10, pigment layer, tapetum.

The *internal nuclear layer* (5, Fig. 26) is about $\frac{1}{1300}$ of an inch thick, and is composed chiefly of oval nucleated nerve-cells, most of which have a single branch or process from each extremity, but a few have no processes. There are a few oval nucleated cells in this layer, connected with the radiating connective-tissue fibres of Müller. All of these cells, have their longer axis perpendicular to the surface of the retina. The branch or process from the inner extremity of these cells, penetrates the inner molecular layer (4, Fig. 26), and communicates with the distal branches from the ganglion-cells in this layer, while the branches from the outer end of the cells penetrate the outer molecular layer (6, Fig. 26), bifurcate, and are supposed to join processes from the inner extremities of the rods and cones. Thus a continuous connection would be established between the

nerve-fibre layer, through the ganglion-cell layer and its processes with this layer, and through this layer and processes with the layer of rods and cones, the perceptive part of the retina. The radiating fibres of Müller, become broader and somewhat granular in appearance in this layer, and have attached to them, or contained in the body of the radiating fibre, the oval nucleated cells mentioned in the beginning of this paragraph.

The *external molecular layer* (6, Fig. 26) is $\frac{1}{2000}$ of an inch thick, and, like the internal molecular layer, is composed of a fine network of very delicate connective tissue, nerve fibrilæ, and of granular material of an unknown nature. In addition, it contains some nucleated stellate cells, having many processes. In this respect, it differs from the internal molecular layer.

The *external nuclear layer* (7, Fig. 26) resembles in structure very closely the internal nuclear layer. It is composed of nucleated cells, ellipsoidal in shape, with the longer axis of the cells perpendicular to the surface of the retina. These cells have branches from both extremities, the branches from the distal extremities join the rods and cones; and are *rod-cells* or *cone-cells*, according as they join a rod or a cone. The rod-cells are much more numerous than the cone-cells, and have transverse striæ on them. The process from the outer extremity joins a rod in Jacob's membrane, while the process from the inner extremity enters the external molecular layer, and swells into a nuclear enlargement from which numerous fine processes are given off. The *cone-cells* are fewer in number, non-striated, and placed close to the external limiting membrane. Like the rod-cells, they have a single process from each extremity, the outer one connecting the cells to the cones in Jacob's membrane, the inner one ending in a bulbous extremity in the external molecular layer.

The *external limiting membrane* (8, Fig. 26) is a membranous expansion of the radiating fibres of Müller, and will be considered under the description of the cellular structure of the retina.

The *layer of rods and cones, or Jacob's membrane* (9, Fig. 26), is the *perceptive* layer of the retina. The rods and cones are placed parallel to one another and perpendicular to the surface of the retina. They are, according to some authorities,

termini of the optic nerve fibres. The rods are much more numerous than the cones. They are divided into two segments, an outer and an inner, which are joined by a sheath surrounding them. These segments differ somewhat in composition and color reagents affect them differently. The *outer* segments of the rods, are marked by fine transverse striæ, which are due to the peculiar formation of the segment; the segment being composed of lamellæ, or discs, of highly refractive molecular substance placed one upon another, and held together by a slightly refractive basement substance. Very delicate longitudinal lines may also be seen on these outer segments, as well as on the outer half of the inner segments of both rods and cones. These longitudinal markings, have been ascribed to fine fibres coming from the rod and cone cells (of the outer nuclear layer), piercing the external limiting membrane and running along these segments in a longitudinal direction. The *inner* segments of the rods, rest on the outer surface of the external limiting membrane. The highly refractive molecular substance, is more abundant in this segment than in the outer segment, the inner portion of the segment having an indistinct granular appearance. The rods measure about $\frac{1}{500}$ of an inch in length and $\frac{1}{8300}$ of an inch in thickness, are cylindrical in shape and almost of a uniform calibre.

The cones are fewer in number than the rods, and like them, are divided into an inner and an outer segment. They are flask-shaped, the broad, rounded extremity resting on the external lining membrane, while the cone part, the outer segment, points outwardly toward the pigment layer, but does not reach it. The composition of the cones is almost similar to that of the rods. The *outer* segment, a pointed extremity, has transverse striæ on its surface, also very faint longitudinal markings. The structure is apparently the same as the outer segments of the rods. The *inner* segment, has striations on its surface similar to those on the inner segments of the rods. Its innermost extremity is granular in appearance, and flares out like a flask, to rest on the outer surface of the external limiting membrane. The structure is the same as that of the inner segments of the rods. The cones measure about $\frac{1}{800}$ of an inch in length and $\frac{1}{5000}$ of an inch in thickness. The existence of axial fibres in the rods and cones is doubtful.

The pigment layer or tapetum (10, Fig. 26) is composed of a single layer of hexagonal nucleated cells containing granular pigment, and held together by a homogeneous cement substance. This layer is closely attached to the limiting membrane of the choroid. Fine stained processes from between these pigment cells extend inwardly to surround the rods and cones, as *pigment sheaths.* In albinos the tapetum is devoid of coloring matter; the choroid also having but little coloring matter in such cases, when seen with the ophthalmoscope, has a bright reddish lustre, which has been designated *tapetum lucidum*, in contradistinction to the term *tapetum nigrum*, ordinarily given to the pigment layer.

This pigment layer perhaps should have been described with the cellular tissue of the retina.

THE CELLULAR OR SUPPORTING TISSUE OF THE RETINA.

This tissue forms the framework for the support of the nervous elements of the retina. It consists of the *internal* and *external limiting membranes* (layers 1 and 8, Fig. 26), and of the radiating connecting fibres of Müller joining these two membranes.

The *internal limiting membrane*, is composed of modified connective tissue, and is formed by the expanded or cone-shaped inner extremities of the radiating fibres of Müller uniting at their bases. This membrane is exceedingly thin (about $\frac{1}{12500}$ of an inch thick), and lies in close contact with the hyaloid membrane of the vitreous.

The *radiating fibres of Müller*, from their cone-shaped bases, which form the internal limiting membrane, extend outward perpendicularly to the surface of the retina, perforating all the layers of the retina between the two limiting membranes. Fine processes are given off from these radiating fibres of Müller, as they go through the different nerve layers, which support the nerve elements by forming delicate meshworks of connective tissue around them. In the inner nuclear layer, these fibres have oval nucleated cells attached to them, or included in the substance of the fibre itself. The radiating fibres run a straight course through the outer nuclear layer, at the outer surface of which they break up into numerous fine fibres, bend at right-angles to themselves, and form the eighth layer of the retina.

The External Limiting Membrane.—This membrane is, therefore, simply a membranous expansion of the external extremities of the radiating fibres of Müller. It is not solid, as is the internal limiting membrane, but has many perforations, through which the processes from the outer ends of the rod and cone cells join the rods and cones.

Macula Lutea, or Yellow Spot of Soemmering.—Situated at the centre of the retina, about $\frac{1}{10}$ of an inch to the outer side of and on a level with the lower border of the optic disc, is a horizontally oval, yellow spot, which is known as the *yellow spot of Soemmering* (Germany, 1804), or *macula lutea* (Fig. 27). At the centre of this yellow spot is a small depression—*fovea-cen-*

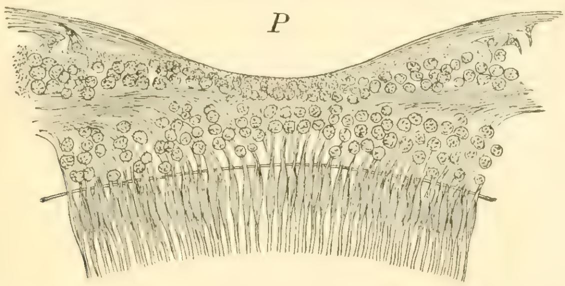

FIG. 27.—MACULA LUTEA. (Landois and Stirling.) *P*, Fovea centralis.

tralis (*P*, Fig. 27). The macula lutea varies in diameter from $\frac{1}{25}$ to $\frac{1}{17}$ of an inch. The fovea centralis, the depression at its centre, is from $\frac{1}{125}$ to $\frac{2}{125}$ of an inch in diameter. The fovea centralis is the centre of direct vision, and is the most sensitive oprtion of the retina.

The structure of the retina at the macula, is different from that in other portions of the membrane.

(1) The internal limiting membrane is very much thinned;

(2) The optic nerve fibres are reduced to a single and almost imperceptible layer, which seems to pass around the macula in curves;

(3) In the ganglion-cell layer, the cells are reduced in size, but greatly increased in numbers and are superimposed one upon another in several layers, instead of a single layer as usual;

(4) The internal molecular layers are wanting;

(5) The internal nuclear layers are thinned;

(6) The external molecular layer is well developed;

(7) In the outer nuclear layer, only cone-fibres remain, and they have a circular course in the macula;

(8) The external limiting membrane is greatly thinned or wanting;

(9) In Jacob's membrane only cones remain, which are lengthened;

(10) The tapetum is unaltered.

The radiating fibres of Müller, do not run perpendicularly to the surface of the retina in the macula, but almost horizontally and radiate toward the fovea centralis as a centre.

In the fovea centralis, the coats of the retina are reduced to the internal molecular layer, which is very much thinned; the external nuclear layer, that has left in it only cone-fibres which run nearly in a horizontal direction, and Jacob's membrane, only the cones of which remain.

Blood-Vessels.—The retina is supplied with blood by the *arteria centralis retina*, which along with its accompanying vein, pierces the optic nerve just back of its entrance into the eyeball, and, through the porus opticus, enters the globe of the eye. On or before entering the eye, the artery divides usually into four main branches, two of which run up and two down, each arterial branch being accompanied by a corresponding vein. A few smaller arterial branches are given off from the central artery, or its main branches, at the optic nerve entrance, which run in a transverse direction in the retina from each side of the disc. These have corresponding veins.

It was the light streak on these smaller vessels, and the edge of the disc, together with the choroidal epithelium near the macula, that Loring took as a standard in measuring the refraction of the eye with the ophthalmoscope.

The retinal vessels on first entering the eye, lie between the internal limiting membrane and the nerve-fibre layer. They soon pierce the nerve-fibre layer, but never go deeper than the internal molecular layer. They divide in an arborescent manner as they proceed, finally to terminate in *free endings*, no anastomoses taking place. There is, therefore, no compensatory circulation in these vessels, when one of them is plugged by an embolus or stopped by a constriction. The retinal vessels never extend further anteriorly, than to the ora serrata. The macula lutea

is richly supplied by fine capillaries, but the fovea centralis has no blood-vessels at all. This and the outer layers of the retina depend for most of their nutrition, on the nutritive lymph thrown out from the capillary layer of the choroid. Posteriorly, the retinal vessels (chiefly arterial, Leber) anastomose with the nutrient vessels of the optic nerve, and indirectly through these with the posterior choroidal and scleral vessels. This is the only connection between the retinal and ciliary vessels of the eye. The retinal vessels, especially the veins, are thought to be surrounded by lymphatic vessels, which pass out of the eye through the cribriform fascia, to join the lymphatic spaces of the optic nerve.

OPHTHALMOSCOPIC APPEARANCES.—The *retinal purple*, or *visual purple*, is a purplish coloring matter in the external layers of the retina. It disappears under the influence of light, but returns again after the light is withdrawn. It disappears altogether after death. This phenomenon is not confined to the human eye alone, but it had been found to exist in many of the lower animals. The retinal purple has not been proven to exist in the fovea centralis in the human eye, and may not, therefore, be absolutely necessary to the act of vision. What knowledge we have on the subject of the visual purple, we owe to the labors of two observers—Professor Boll, of Rome, and Professor Kuhne, of Heidelberg.

The Light-Ring Seen at the Macula.—This light ring at the macula does not always appear as a complete ring or circle, but may appear in the shape of a half-circle, or in the shape of a triangle, all of which forms may be seen in one eye at a single sitting, simply by rotating the mirror of the ophthalmoscope a little, or if the patient move the eye slightly. Again, any of them may be seen in an eye to the exclusion of the rest, while sometimes the macula is seen simply as a yellowish white spot. These different appearances at the macula seem to be, as Loring maintains, the products of reflection and refraction from the combination of curved surfaces which enter into the construction of the retina at this point.

Reproducing a figure of the macular region (after Schultze), which is again produced, Loring remarks:

"As you will see, this region, as figured in the diagram (Fig.

27), bears in its formation a strong resemblance to a shallow cup, of which the rim is represented by a convex, and the bow by a concave, surface. If we look upon these curved surfaces as mirrors, they would each have their foci, one lying behind the other in front, according to their respective degrees of curva-

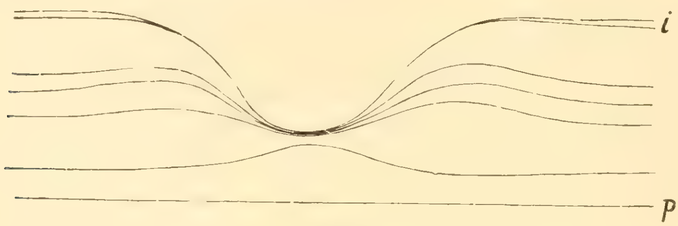

FIG. 28.

ture. And if light should be thrown perpendicularly against such a combination of curves, the apex of the outside vein or convex surface would, from well-known optical laws, appear illuminated, while the inside or concave surface would appear more or less in shadow. Thus we would have the effect of a darker centre, surrounded by an illuminated edge."[1]

Should the light be thrown on to one side of the cup, the "half-circle" illuminated rim would appear, and if the summit of the half-circle was elongated or drawn out a little the "triangular" appearance, it seems to me, could be accounted for. Should there be no depression at the macula, then, as is sometimes the case, only a yellowish white spot would appear at the macula.

The Light-Streak on the Retinal Vessels.—On looking into the fundus of the eye with the ophthalmoscope, a bright line is seen apparently along the summit of the vessels, both arteries and veins. On the arteries this light-streak is a little brighter and narrower than on the veins; otherwise they are the same. This light-streak is always present in the vessels in normal eyes. In any diseased condition of the refractive media, preventing a proper illumination of the retina, it is modified or obscured, and in detachment of the retina it is usually absent altogether on the detached portion; especially is this so in marked cases of detachment.

[1] Stellwag on the Eye (English translation), 1873, p. 158.

The cause of this light-streak on the retinal vessels has been a subject of much discussion. Some observers have maintained that it was produced by the *reflection* of light from the summit of the vessel wall, or from the summit of the blood-column in the vessels (Van Trigt, Jaeger, Schneller, Donders, Story, and others), while Loring, Noyes, De Schweinitz and Davis, have contended that it was due to the *refraction* of rays of light passing through the blood-vessels and blood-column, striking the underlying tissue, being reflected slightly by the posterior wall of the vessel, but chiefly by the underlying tissue, back through the vessel and blood-column into the eye of the observer, the refractive action of the blood-column condensing the light as it passes through it both ways, just as a bi-convex lens would do, and that the light-streak is thus caused.

Van Trigt[1] was the author of the first theory of reflection, 1853; Loring[2] of the opposing theory of refraction, 1870. Van Trigt's theory of reflection was generally accepted until 1870, when Loring presented the theory of refraction. This last theory, however, was strongly attacked by Schneller,[3] F. C. Donders, and others. Knapp[4] was of the opinion that Schneller's experiments and statements are in part, at least, as far as could be judged without repeating them, correctly refuted by Loring. Donders claimed that Loring's theory would not hold, because in his experiments he had used a carmine solution to represent a warm blood-column, when they were entirely different. He did not, however, question the validity of the experiment had it been conducted with the blood-column of a warm-blooded animal. Davis[5] repeated Loring's experiment on a column of blood from a warm-blooded animal, and obtained the same results that Loring did with the carmine solution, thus sustaining his theory of refraction. He went one step further, however, repeating Becker's experiment with the microscope on cold-blooded animals and on warm-blooded animals, again sus-

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[1] "Dissertat. ophthal. inauguralis de Speculo Oculi," Utrecht, 1853.

[2] Trans. Amer. Ophthal. Soc., p. 122, 1870, also Arch. Oph. and Otol., ii., 1, pp. 95–106.

[3] "Ergebnisse d. Untersuchung d. mensch. Aug. m. d. Augenspiegel."

[4] Knapp's Arch. of Oph. and Otol., vol. iv., No. 1, p. 147.

[5] Knapp's Arch. of Oph., vol. xx., No. 1, 1891.

taining Loring's theory. Story[1] questioned and opposed these experiments of Davis, but Davis[2] still maintained his position. Space is too limited in this volume to give any of the experiments referred to, but the reader is referred to the different papers cited for a full discussion of the subject. In my opinion, the theory of refraction in accounting for the phenomenon of the light-streak on the retinal vessels, is sustained by the physiological experiments of Loring and Davis.

PHYSIOLOGY.—The retina is the organ of *perception* of the eye, and the rods and cones are the seat of this function of perception. The perception of an object depends upon the power of the retina to convert rays of light into nerve stimuli. For it is by means of the rays of light from an object entering the eye that an image of the object (always in an inverted position to the object itself) is formed on the retina. We do not know exactly by what procedure the waves of light-rays are converted into nerve stimuli, or, to present it in another way, how the waves of light impinging on the rods and cones excite them to action, with

FIG. 29. A TEST FOR THE BLIND SPOT OF MARIOTTE.—In the normal field there is always a blind spot, corresponding to the optic disc, the fibres going to which are insensible to light. This is called the blind spot of Mariotte, after the man who first described it (Mariotte, France, seventeenth century). Under ordinary circumstances this blind spot is not noticed and occasions no inconvenience. By a simple experiment the existence of Mariotte's spot may be determined by the aid of the picture here presented. If the picture be held say twelve inches away, and the eye fixed upon the cross, representing the macula, and very slowly approached to the eye, then comes a point when the white ring disappears entirely from view.

the resultant impression on the cones being transferred to the brain as *perception* of light or of an object, if its image is thrown upon the retina. What we do know is, that both physical and chemical changes take place in the retina during the act of per-

[1] Ophthal. Review, London, xi., pp. 100–108. [2] *Loc. cit.*, pp. 253–258.

ception when light is thrown upon it. The physical changes, first, consist in a contraction and shortening of the rods and cones; second, the pigment granules in the epithelial cells of the pigment layer of retina are drawn from the outer portion of these cells to the inner portion, under the influence of light.

The spot in the retina of most acute perception is the fovea centralis, the centre of direct vision. Each cone in the fovea is supposed to have a separate cone-fibre running to it, whereas in other portions of the retina this is not the case. This is the reason that vision is most acute at the fovea.

Senile Changes.—The supporting connective-tissue framework is chiefly affected by these changes, the nervous elements and blood-vessels to a less degree. The connective tissue becomes sclerosed, the radiating fibres of Müller and the limiting membranes appearing cloudy from deposits of organic detritus, which give to the retina in the aged a dirty, grayish-white appearance. These changes may be uniform over the retina, or affect only localities. The nerve-fibre layer is the seat of senile changes also. In this layer are often found masses of amyloid and colloid substance, which has a high index of refraction. These spots give to the retina a stippled white appearance, which may be mistaken for the changes which take place in cases of albuminuria.

The vessels and capillaries often undergo a form of fatty degeneration.

ANATOMY OF THE OPTIC NERVES.

The optic nerves are nerves of a special sense—that of sight. Through these nerves, impressions made upon the retina are transmitted to the brain. They have their origin in the brain as the optic tracts, which emerge from its under surface at the posterior portion of the optic thalami by two roots. The inner root arises from the posterior portion of the *optic thalamus*, and passes forward through the *inner geniculate* body, a few fibres from this body joining the root. The outer and longer root arises from the optic stratum of the *corpora quadrigemina*, and passes forward between the inner and outer geniculate bodies to join the other root at the posterior, inferior portion of the optic thalamus, thus forming the optic tract. From the root

arising from the optic thalamus, fibres have been traced (Meynert, Gratiolet) through the internal capsule and the white substance of the occipital lobe, to the *cortical substance* of the *occipital lobe*, most of them terminating in ganglion cells in the cuneate portion, which is the visual area of the cortex of the brain. Other fibres have been traced into the *crus cerebri*, *olivary bodies*, and *crus cerebelli* to the floor of the fourth ventricle to the *nuclei of origin* of the third nerve, and from the flattened surface of the optic tract lying next to the crus cerebri, fibres have been traced into the *tuber cinereum* and *lamina cinerea.*

The *optic tracts* (T and $T_{\prime}$, Fig. 30) from the above sources of origin proceed, as flattened masses of medullary fibres devoid of neurilemma, along the under surfaces of the *crura cerebri*, to the olivary process of the sphenoid bone. Just in front of the olivary process, the fibres from the inner side of each optic tract cross to form the optic chiasm or commissure (s s, Fig. 30), which rests in the optic groove in front of the olivary process. The *optic chiasm* is formed as follows: The fibres on the outer side of each tract, to the extent of about two-fifths of all the fibres, pass without decussating into and form the outer side of each optic nerve, continuing to the temporal side of retinæ in each eye (r and $r_{\prime}$, Fig. 30). The fibres of the inner side of each tract, the remaining three-fifths, cross or decussate, the fibres from the inner side of right tract (T, Fig. 30) going to the inner side of the left optic nerve ($O_{\prime}$, Fig. 30); the fibres from the inner side of left optic tract ($T_{\prime}$, Fig. 30) going to the inner side of right optic nerve (O, Fig. 30). These fibres supply the nasal side of each retina, bending out a little at the maculæ to include them on the nasal side of retinæ. At the optic chiasm, only a semi-decussation of the fibres of the optic tracts takes place, a little more than one-half or about three-fifths only of the fibres decussating.

The *optic nerves* proper (O and $O_{\prime}$, Fig. 30), have their origin in the anterior lateral portions of the chiasm, and are composed of fibres from both optic tracts, as just seen in the description of the chiasm. About two-fifths of the fibres of each nerve are derived from the optic tract of the same side; the remaining inner three-fifths, from the inner side of the optic tract of the opposite side. From their origin at the

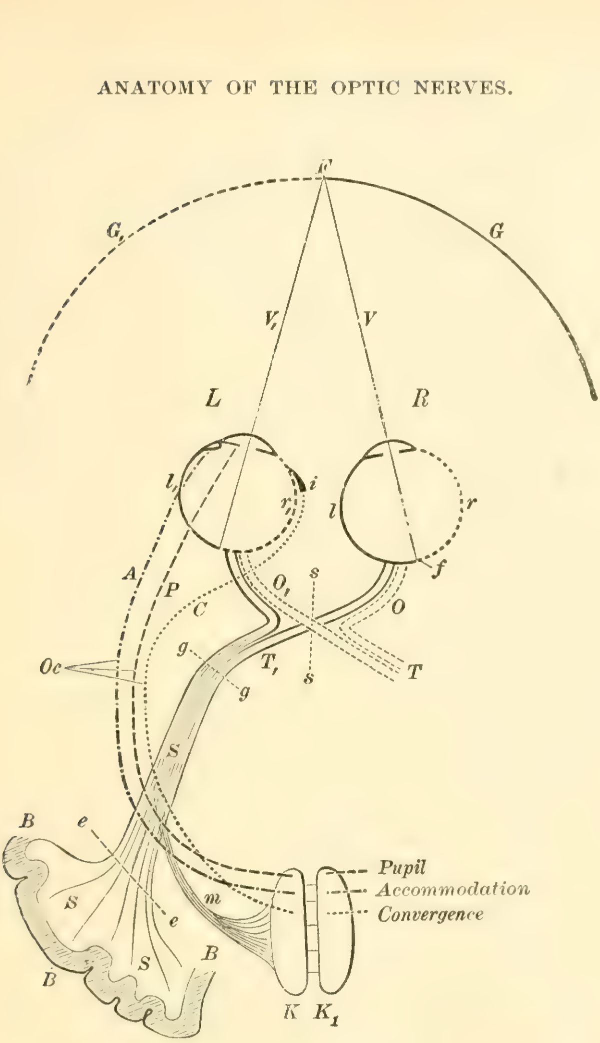

FIG. 30.—SCHEMATIC REPRESENTATION OF THE OPTIC TRACTS. (After Fuchs.) The field of vision common to the two eyes is composed of a right half, G, and a left half, $G_,$. The former corresponds to the left half, l and $l_,$, of the two retinæ, the latter to the right half, r and $r_,$; the boundary between the two halves of the retina is formed by the vertical meridian. This passes through the fovea centralis, f, in which the visual lines drawn from the fixed point, F, infringe upon the retina. The optic nerve fibres arising from the right half, r and $r_,$, of the two retinæ (indicated by the dotted line), all pass into the right optic tract, T, while the fibres belonging to the left half, l and $l_,$, of the two retinæ pass into the left optic tract, $T_,$. The fibres of each optic tract for the most part pass to the cortex of the occipital lobe, B, forming Gratiolet's optic radiation, $S_,$; the smaller portion of them, m, goes to the oculo-motor nucleus, K. This consists of a series of partial nuclei, the most anterior of which sends fibres, P, to the pupil (sphincter iridis); the next one sends fibres, a, to the muscle of accommodation, and the third sends fibres, C, to the converging muscle (internal rectus, i). All three bundles of fibres run to the eye in the trunk of the oculo-motor nerve, $O\,c$. Division of the optic tract at $g\ g$ or $e\ e$ produces right hemiopia; and in the former case there would be no reaction to light on illuminating the left half of either retina. Division of the chiasm at $s\ s$ produces temporal hemiopia. Division of the fibres m abolishes the reaction of the pupil to light, but leaves the sight and also the associated contraction of the pupil in accommodation and convergence unaffected.

chiasm, they advance in diverging courses to the optic foramina, a distance of five to seven lines. This is known as the cranial portion of the optic nerve. From the optic foramina to the posterior surface of the eyes, the optic nerves proceed in a double curved course to enter the eyeballs about two lines to the inner side of the posterior pole. The length of the nerve to the posterior surface of the eyeball is about $1\frac{1}{8}$ inches. The crooked course of the optic nerve through the orbit to the posterior surface of the eye, allows free movement of its posterior pole, which would be impossible if the nerve went in a straight course and was kept on a stretch. Within the eye the optic nerves spread out to form the nerve-fibre layer of the retina.

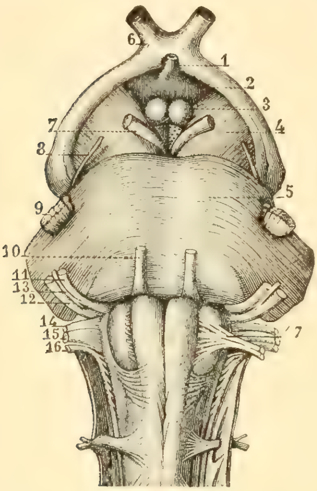

FIG. 31.—INTRACRANIAL PORTION OF THE OPTIC NERVE. (From Sappey.) 1, Pituitary body; 2, tuber cinereum; 3, mammillary tubercles; 4, cerebral peduncle; 5, annular protuberance; 6, the optic nerves and the chiasm; 7, motor oculi (third nerve); 8, fourth nerve; 9, trifacial nerve; 10, sixth nerve; 11, facial nerve (seventh); 12, auditory nerve; 13, Wrisberg's nerve; 14, glosso-pharyngeus; 15, pneumogastric; 16, spinal nerve; 17, hypoglossal.

STRUCTURE.—The OPTIC TRACTS and CHIASM, are composed of medullary nerve fibres held together by neuroglia. Both the tracts and the chiasm, are devoid of neurilemma. The blood-vessels of the tracts and the chiasm, are derived from the vessels supplying the anterior portion of brain and pia mater.

The OPTIC NERVES are composed of medullary nerve fibres, connective tissue, and blood-vessels, and are surrounded by a sheath of pia mater (its neurilemma), while the orbital portion is surrounded in addition by two other membranes, arachnoid and dura mater. Lymph spaces are found in the trunk of the nerve and between its sheaths in the orbit. *Cranial portion:* The trunk of the nerves is composed chiefly of medullary fibres collected into small bundles, the fibres in the bundles being held together by neuroglia, as in the optic tracts and chiasm. The bundles themselves are surrounded and supported by connective-tissue fibres and sheaths, from the inner surface of the pia mater surrounding the nerves. The nutritive blood-

vessels of the nerves ramify in this supportive connective tissue between the bundles, the two together—blood-vessels and connective tissue—forming about one-third of the bulk of the nerve. Between the individual nerve bundles, and the sheaths of connective tissue surrounding them, are narrow spaces, supposed to be lymph spaces (Fuchs). This portion of the nerve has but one sheath, the pia mater, from the inner surface of which, the supportive connective tissue between the nerve bundles is derived. It is closely attached to the nerve, and extends from the chiasm to the optic foramina and through them on to the orbital portion of the nerve. *Orbital portion:* The structure of the orbital portion of the optic nerve, from its entrance into the orbit at the foramen as far forward as the *lamina cribrosa*, is similar to that of the cranial portion, with this exception—it has three sheaths surrounding it, while the cranial portion has but one. The trunk of the orbital portion, being similar in structure to that of the cranial portion already given, it remains

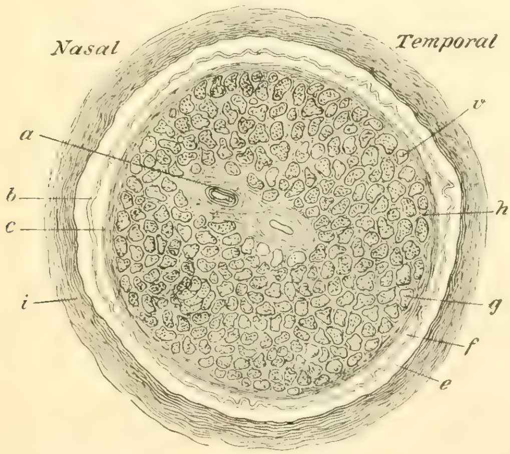

FIG. 32.—CROSS-SECTION OF THE OPTIC NERVE, ORBITAL PORTION ¼ INCH BACK OF THE EYEBALL. (H. T. Potter *del.*) *i*, External sheath (dura mater); *b*, middle sheath (arachnoid); *c*, internal sheath (pia mater); *e*, subdural space; *f*, subarachnoid space; *g*, optic nerve bundles surrounded by connective tissue, *h*, from the internal sheath; *a*, central artery of the retina; *v*, central vein (the line leading from *v* should extend to the vein at the centre of optic nerve).

but to describe its sheaths and the spaces between them. The innermost sheath is of pia mater (*c*, Fig. 32), a direct continuation of the pia mater surrounding the cranial portion of nerve. It adheres closely to the nerve, sending into it from its

inner surface sheaths of connective tissue to surround the nerve bundles, just as in the cranial portion. Anteriorly, the pia mater terminates in the inner layers of the sclerotic. External to the pia mater, is a very delicate sheath (*b*, Fig. 32), which is a continuation of the arachnoid membrane of the brain from the optic foramen forward to the sclera, where it terminates in the scleral tissue just external to the fibres of the pia mater. The outermost membrane (*i*, Fig. 32) is composed of dura mater, a direct continuation of the dura mater of the brain from the optic foramen forward to the posterior surface of the eyeball, where it enters into and forms the outer two-thirds of the scleral tissue. Between the dura mater and arachnoid, there is a space (*e*, Fig. 32)—*sub-dural space;* between the pia mater and arachnoid is another space (*f*, Fig. 32)—*sub-arachnoid space.* Posteriorly, these spaces are connected with spaces of a similar character in the brain; anteriorly, they terminate in blind extremities in the sclera. They are lined with endothelium as are other lymph-spaces.

The structure of the optic nerve, at the point where it enters the eyeball through the sclera and choroid, is somewhat different from that in its other portions. At this point it is reduced in diameter from $1\frac{1}{3}$ lines to $\frac{2}{3}$ of a line, or just one-half. This reduction in size of the nerve at this point, is at the expense of nerve tissue, the nerve fibres losing their medullary sheaths, only the axis cylinders remaining. The nerve fibres up to this point are opaque, owing to the medullary sheaths which surround them; from this point forward into the retina, where the nerve fibres spread out as the nerve-fibre layer of the retina, these fibres are of a grayish, translucent appearance, only the axis-cylinders of the fibres remaining, which are all but transparent.

The manner of distribution of these fibres in the retina itself is to be noticed. The fibres near the centre of the nerve, are the longest and go the periphery of the retina, the longest of these being the temporal fibres just above and just below the macular bundle of fibres, the shortest those going to the nasal side of the retina. The fibres near the periphery of the nerve, are the shortest and terminate near the optic nerve entrance. There is a special bundle (macular bundle) which goes to the region of the macula. These fibres spread out from the temporal side of

the optic nerve, in the shape of a wedge, the base of the wedge embracing the macular region of the retina, hence the name *macular* bundle of fibres. The fibres in this macular bundle, are much finer than the other fibres of the nerve, and comprise from one-fourth to one-third of all the fibres in the nerve. In the immediate macular region an independent fibre is supplied to each cone in Jacob's membrane, which is supposed to account for the fact that most acute vision is at this part of the retina. Furthermore, the fibres from the macular region of the retina decussate at the chiasm and send part of their fibres to each side of the brain, while the fibres to the right side of the macula in each eye, go to the right side of the brain alone, and those to the left side of the macula in each eye, go to the left side of the brain alone. The extreme acuteness of vision, therefore, in the region of the macula, may be accounted for not only by its anatomical formation and its extra number of nerve fibres, but perhaps by the additional fact that the impressions on the macula of each eye, are carried to both sides of the brain and not to one side alone.

Lamina Cribrosa.—At the point where the nerve pierces the inner layers of the sclera, and where the nerve bundles lose their medullary sheaths, numerous bands and fibres of connective tissue, stretch across the scleral opening. These bands and fibres are a continuation of the innermost layers of the sclera, directly across the course of the optic nerve fibres. A few connective-tissue fibres from the margin of the choroidal opening, reinforce those from the inner layers of the sclera. This layer of connective-tissue fibres, from the inner layer of the scleral and choroidal ring are pierced by many small foramina for the passage of the separate bundles of optic nerve fibres into the eye. Near the centre, is a larger opening than the majority of the perforations, which is for the passage of the central artery of the retina, and is known as the *porus opticus*. It is from these many small openings that the name—*lamina cribrosa*—is derived. The *lamina cribrosa*, composed as it is of but one thin layer of connective-tissue fibres, and this perforated by many small openings, is the weakest point in the walls of the eye. Hence the predominancy of *posterior* staphylomata over all other forms, especially in myopic eyes. Pressure being exerted equally on

all parts of the inner surface of the walls of the eye, the point of least resistance gives way first, and this is usually at the lamina cribrosa.

Optic Disc.—Immediately on entering the eye, the bundles of optic nerve fibres bend at almost right angles to enter the nerve-fibre layer of the retina, which layer they compose. (See minute description of this layer under the anatomy of the retina.) The transparent optic nerve fibres (composed only of axis cylinders here), filling up the space between the scleral and chorioidal openings internal to the lamina cribrosa, go to form the optic disc (*B*, Fig. 33). The disc is on a level with the inner retinal

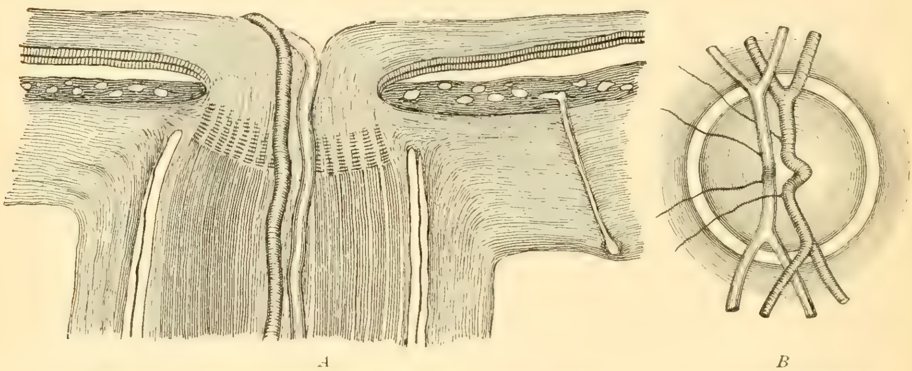

FIG 33.—OPTIC NERVE ENTRANCE INTO THE EYE. (After Fuchs.) *A*, Section showing lamina cribrosa; *B*, ophthalmoscopic view of disc.

surface, and measures about $\frac{2}{3}$ of a line in diameter. In the centre of the disc there is usually a slight depression, due to the bundles of optic nerve fibres beginning to separate at the centre of the nerve immediately after they have traversed the lamina cribrosa. In the living subject, with the ophthalmoscope, at the inner or nasal side of this depression the central artery and veins are seen. The arteries, to the inner side of the veins, are easily distinguished from the latter by their lighter color and smaller size. External to the vessels at the bottom of this cupping, can be seen the openings in the lamina cribrosa, filled with the transparent bundles of nerve fibres, giving to this part of the disc a grayish stippled appearance. Between this central cupping in the disc and its margin, it normally has a yellowish-red appearance, the numerous small blood-vessels traversing the disc, giv-

ing it this appearance. At the margin of the disc, a narrow white ring is often found, which may extend entirely around the margin of the disc (*B*, Fig. 33), or may be limited to the temporal side of the disc as a crescent. This is simply the margin of the scleral opening, extending slightly beyond that of the choroidal at the entrance of the nerve into the eye. A black ring of choroidal pigment, may surround the margin of the disc external to the white scleral ring, in whole or in part; or it may be present while the scleral ring is absent.

BLOOD-VESSELS.—The arteries to the optic tracts, chiasm, and cranial portion of optic nerves are from the pia mater. The pia mater derives its blood supply from the internal carotid and vertebral arteries. The orbital portion of the optic nerves also receives branches from the pia mater. Branches from the ciliary and muscular arteries of the ophthalmic, pierce its sheaths and help to supply it, however. The arteries to the nerve, penetrate it along the connective-tissue sheaths given off from the inner surface of the pia mater (neurilemma) surrounding it. Anteriorly, five to ten lines posterior to the entrance of the optic nerve into the eyeball, it is penetrated obliquely by the *central artery of the retina*, which is surrounded by a special sheath of its own of connective tissue. This artery penetrates to the centre of the nerve, along which it passes forward to the porus opticus, its special opening in the lamina cribrosa, through which it enters the eyeball to be distributed to the retina. This artery seldom branches until it reaches the optic papilla, where it is usually divided into two branches, an upper and a lower. (For final termination of these arteries see the blood supply of the retina.) The veins from the optic nerve, empty into the central vein and the ophthalmic vein. The vein corresponding to the central retinal artery, accompanies it in the centre of the nerve but is inclosed in a separate sheath of connective tissue of its own. This central vein is nearer the centre of the optic disc than the central artery, which is nearer the nasal side. It leaves the nerve, a little closer to the eyeball than where the central artery enters it. As a general thing, this vein empties directly into the cavernous sinus, not, however, until anastomosing by several branches with the ophthalmic veins.

The small arteries and veins of the papilla are from the nu-

trient vessels of the nerve. These are from the central retinal artery and the muscular and ciliary branches of the ophthalmic. These fine branches anastomose with retinal and choroidal vessels—a connection between the ciliary vessels and retinal vessels is thus established.

PHYSIOLOGY.—The function of the optic nerves, chiasm, and optic tracts is to transmit retinal impressions to the brain. Those impressions which are transmitted to the cortex of the brain in and around the cuneate lobe, the visual centre, result in the conscious perception of the retinal image, that is, vision. We may have unconscious sight, however, that is, objects may be properly imaged on the retina and transmitted accurately to the brain, but, if from any cause the ganglion cells in the cortex of the visual centres are diseased or impaired, or if the mind be intent on other objects the retinal images are not recognized as such. The objects are seen but the observer is unconscious of the fact. This unconscious seeing of objects, may take place when there is no disease of the cortex of the brain at the visual centres, as in somnambulists or sleep-walkers. People walking in their sleep have their eyes wide open, objects are imaged on their retinæ, transmitted to the visual centres, and are seen, but unconsciously. Furthermore, unconscious cerebration sometimes takes place in these cases, enabling them to perform feats, such as walking upon narrow window-sills, edges of roofs, and so forth, which perhaps they could never perform with conscious sight and conscious cerebration. Those fibres from the optic tracts (*m*, Fig. 30) which are traced to the ganglion cells at the origin of the oculo-motor or third nerve, control the reflex action of the pupil. Light impinging on the retina, makes an impression which is transmitted along the optic nerves and tracts to the nucleus of the third nerve, from here it is transmitted back along the third nerve to the pupil, which contracts, and as the result of the original stimulus to the retina. The associate action of the pupils and the associate action of the muscles are presided over by associate or co-ordinate centres; while the voluntary actions of the eye, are presided over by centres situated in the cortex of the brain.

The origin of the fibres which form the optic tracts, their

exact arrangement in the tracts, chiasm, and optic nerves, and their final distribution and termination in the retinæ, should be carefully studied to understand the especial function that the fibres forming each tract have to perform. In fact, a thorough knowledge of these points is absolutely necessary in making correct diagnoses of various affections of the brain, tracts, chiasm, optic nerves, orbits, and so forth.

It is apparent from a glance at Fig. 30 that the fibres from the right optic tract supply the right side of both retinæ—the temporal side in the right eye and the nasal side in the left eye, while the fibres from the left tract supply the left side of both retinæ—the temporal side of the left and the nasal side of the right. Now, since it is a fact, that the images of objects situated to the left of the median line (*F*, Fig. 30) are formed on the right side of each retina, it is evident that these images must be transmitted along the temporal side of the right optic nerve and nasal side of left optic nerve to the chiasm, from here into the right optic tract, thence to the right cortex of the brain, where they are perceived. Again, the images of objects situated to the right of the median line are formed on the left side of each retina. These images are transmitted along the temporal side of the left optic nerve, and the nasal side of the right optic nerve to the chiasm, from here into the left optic tract, thence to the cortex in the left brain, where they are perceived. It follows, therefore, that objects situated on the left side of the median line, are perceived by the right side of the brain, and objects situated on the right side of the median line are perceived by the left side of the brain. But if the eye is fixed upon an object in the median line, it is perceived by both sides of the brain at the same time. This is true of all fixed objects, whether on the median line or not. The image of a fixed object, which we will say is on the median line at *F*, Fig. 30, is formed on the temporal side of each retina, and especially plain on the macula of each retina. The images from the different parts of this object are transmitted to both sides of the brain, and independently by each eye. The images on the temporal side of each retina are transmitted to the outer side of each nerve respectively, which go uninterruptedly into the outer side of each tract at the chiasm, and from thence to the same

side of the brain. But the images on each macula, are transmitted along the inner side of each nerve to the chiasm, and, as the optic-nerve fibres to the macular region in each eye, partly decussate at the chiasm, sending some fibres to each side of the brain, images formed on the maculæ, go independently from each macula to both sides of the brain. Images formed on the nasal side of each retina, are transmitted to the inner side of the optic nerves, which carry them to the opposite side of the brain relative to the retina on which they are formed. It is evident from the foregoing, that all fixed objects are perceived by both sides of the brain, while objects that are not fixed are perceived by one side only, those to the left side of the median line by the right side of the brain, and those to the right side of the median line by the left side of the brain.

Knowing the origin, course, and distribution of the fibres of each optic tract, and the function they perform, the location of any lesion which may interfere with a proper performance of their function can be determined. For example, a lesion in the right optic tract, or in the cortex of the brain at the visual centre on that side, for that matter, would result in a want of perception of unfixed objects situated to the left of the median line, and the want of perception of the left halves of all fixed objects. This results from the fact, that all unfixed objects to the left of the median line, and the left halves of all fixed objects are imaged on the right side of each retina. But as the right side of each retina is supplied by the fibres from the right optic tract, and this being diseased in this case, these images are not carried to the brain at all. Consequently, the left half of each field of vision is cut off, resulting in the seeing of only the right halves of all fixed objects. Seeing half of objects only, is called *hemiopia*. In the supposed case just cited, it would be left hemiopia, and homonymous at the same time, as the left side of each field is cut off, leaving only the right halves of fixed objects to be seen. A lesion situated in the chiasm at the decussation of the inner fibres of the tracts (*s s*, Fig. 30), would result in a want of perception of objects imaged on the nasal side of each retina, and, consequently, a cutting off of each temporal field—*temporal hemiopia*. A lesion in the optic nerve anterior to the chiasm re-

sults in a disturbance of function in one eye only, that is, if the lesion is limited to one nerve.

ANATOMY OF THE ORBIT.

The orbits are the bony cavities in which the eyeballs are contained and by which they are protected. They are quadrilateral-shaped cavities, having the form of four-sided pyramids with rounded angles; the bases of the pyramids, the anterior openings of the orbits, are directed forward and outward. The apices, the posterior openings or optic foramina, are directed backward and inward (*c*, Fig. 34). The axes of the orbits, lines joining the centre of the apex to the centre of base, are directed from without backward and inward on a horizontal plane, inclined to each other at an angle of 42° to 45°, so that if prolonged from the apices of the orbits they would meet back of the sella turcica over the body of the sphenoid bone. The average depth of the orbits is about $1\frac{3}{5}$ inches.

Seven bones enter into the formation of each of the orbits: the frontal, sphenoid, ethmoid, superior maxillary, palate, lachrymal, and malar. Three of these bones, the frontal, sphenoid, and ethmoid, help to form both orbits, therefore, there are but eleven bones in the composition of both orbits. In a description of the orbits the walls, angles, base, and apex are to be considered.

WALLS.—The *superior wall* or *roof* of the orbit is formed by the orbital plate of the frontal bone anteriorly, and by the orbital surface of the lesser wing of the sphenoid bone posteriorly. The roof which separates the orbit from the cranial cavity and the frontal sinus, is very thin and sometimes perforated, leaving dura mater and peri-orbita to separate the orbit from the cranial cavity. The roof is not a perfectly plane surface, but is concave, and at its anterior, external portion presents a rather deep concavity, *fossa lachrymalis*, for the reception of the lachrymal gland. At its inner anterior angle is a smaller depression—*fovea trochlearis*—in which the pulley of the superior oblique muscle rests. In the posterior portion of the roof a transverse suture joins the orbital surfaces of the frontal and lesser wing of the sphenoid bones. The *inferior wall* or *floor* of

the orbit is formed by the orbital plates of the superior maxillary, malar and palate bones. The first-named bone forms the greater part of the floor. The floor of the orbit separates the orbit from the antrum in the superior maxillary bone, is thicker than the roof and has a slightly concave surface, the posterior portion of which slants upward to the optic foramen. Near the centre of its surface, running from behind forward, is the infraorbital groove, changed into a canal as it passes forward to open on the face about two lines below the lower

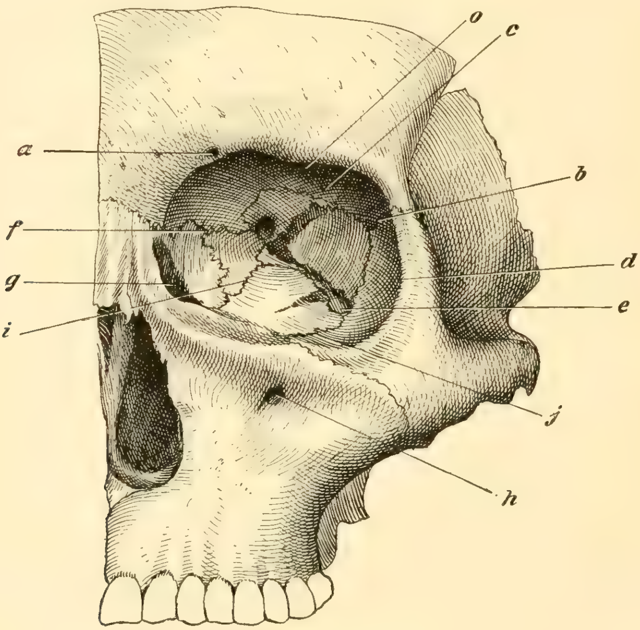

FIG. 34.—ANTERIOR VIEW OF THE ORBIT. *a*, Supra-orbital notch or foramen; *f*, superior internal angle; *g*, lachrymal groove; *i*, inferior internal angle; *h*, infra-orbital foramen; *j*, inferior external angle; *d*, external rim of orbit; *b*, external superior angle of orbit, the sphenoidal fissure forming the inner part of it; *e*, spheno-maxillary fissure; *c*, optic foramen (the line from *c* not quite reaching to it).

orbital margin (*h*, Fig. 34). Through this canal the infra-orbital vessels and nerve pass. At the anterior internal portion of the floor, just external to the lachrymal groove, is a small depression, from which the inferior oblique muscle has its origin. Near its posterior portion, is a suture joining the orbital plates of the superior maxillary and palate bones, and near the anterior external portion a suture (*j*, Fig. 34) between the superior max-

illary and the malar bones. The inner wall approaches nearer to a plane surface than any of the other walls of the orbit and is almost perpendicular. The nasal process of the superior maxillary, lachrymal, os planum of the ethmoid, and the body of the sphenoid, enter into its formation. The inner wall is very thin, measuring only about $\frac{1}{11}$ to $\frac{1}{5}$ of a line in thickness. Anteriorly, this wall presents the lachrymal crests and between them the lachrymal groove (*g*, Fig. 34), for the reception of the lachrymal sac; also the suture joining the lachrymal and ethmoid bones, and further back the suture between the ethmoid bone and the body of the sphenoid bone. The outer wall of the orbit is formed by the orbital plate of the malar bone and by the orbital surface of the greater wing of the sphenoid bone. It is the thickest and stoutest wall of the orbit, measuring about one line in thickness. There are two or three small openings or foramina in the outer wall anteriorly, which transmit small nerve branches—the temporal and malar of the superior maxillary, and the malar branches of the lachrymal artery. A vertical suture, joining the orbital surfaces of the malar and the greater wing of the sphenoid bones, extends across the middle of the outer wall.

ANGLES.—The superior internal angle extends along the suture joining the frontal, and the upper margins of the lachrymal and ethmoidal bones (*f*, Fig. 34). In this suture between the frontal and ethmoid bones are two small openings—the *ethmoidal foramina*. The anterior one transmits the anterior ethmoidal artery and vein and the nasal nerve, the posterior one the posterior ethmoidal vessels. The inferior internal angle extends along the suture between the inferior margins of the lachrymal and os planum of the ethmoid, and the inner margins of the orbital surfaces of the superior maxillary and palate bones (*i*, Fig. 34).

The inferior external angle is formed in part by the spheno-maxillary fissure (*e*, Fig. 34), and by an imaginary line from the anterior extremity of this fissure straight forward to the margin of the orbit. The spheno-maxillary fissure transmits the infra-orbital artery, the superior maxillary nerve, the orbital branch of the same nerve, and the ascending branches from the spheno-palatine ganglion. The superior external angle (*b*, Fig.

34) extends along the suture between the frontal, malar, and greater wing of the sphenoid bones into the sphenoidal fissure, which forms the posterior portion of the angle. The sphenoidal fissure transmits the third, fourth, the ophthalmic division of the fifth, and the sixth nerves, and a few branches from the cavernous plexus of the sympathetic nerves, the ophthalmic vein, a recurrent branch from the lachrymal artery, and the orbital branch of the middle meningeal artery.

Base.—The base of the orbit is its facial opening, which measures in the adult about $1\frac{3}{5}$ inches in width and $1\frac{1}{3}$ inches in height. It is bounded by a strong, bony rim on three sides, upper, outer, and lower. Above, the rim is formed by the thickened orbital margin—*supra-orbital* arch of the frontal bone; externally, by the thickened orbital margin of the malar bone and external angular process of the frontal; below, by the thickened orbital margins of the superior maxillary, malar, and lachrymal bones. Internally, the nasal process of the superior maxillary and internal angular process of the frontal are not thickened into a distinct rim as on the other three sides, but slant off gradually to join the nasal bone. The bridge of the nose, however, protects the eyeball on the inner side. The rim of the orbit is pierced or notched above about one inch from the median line of the skull by the supra-orbital notch or foramen (*a*, Fig. 34) for the passage of the supra-orbital vessels and nerve. There are also three sutures in the rim of the orbit; externally, a suture between the external angular process of the frontal and the malar bones; internally, between the nasal process of the superior maxillary and the frontal bones; and inferiorly, between the malar and the superior maxillary bones.

Apex.—The apex of the orbit is represented by the optic foramen. From the foramen, the canal leading into it, passes backward, upward, and inward between the roots of the lesser wing of the sphenoid bone into the middle fossa of the skull. It is about four lines in length and three lines in width. The optic nerve and ophthalmic artery, pass into the orbit through this foramen.

Soft Structure.—The bony orbit is lined by a layer of dense connective tissue, the periorbita, which corresponds to the periosteum lining other bony surfaces. This fascia-like layer of connec-

tive tissue is more closely attached to the margins of the fissures and foramina leading into the orbit, and to the rim of the orbit than at other portions. At the edges of the fissures it joins the dura mater, and at the rim of the orbit with the periosteum of the bones of the face. From the inner surface of the periorbita, numerous fibres and bands of connective tissue spring, which, in some places, are widened into broad sheaths or fasciæ. These connective-tissue fibres, bands, and sheaths serve to connect the contents of the orbit—eyeball, muscles, optic nerve, lachrymal gland, vessels, nerves, lenticular ganglion, and fat—with each other and with the bony orbit. In the posterior portion of the orbit, between its apex and the posterior surface of the eyeball, these connective-tissue fibres form a close network around the optic nerve vessels and nerves joining them together; the interspaces between the fibres being filled with fat, a cushion is formed for the eyeball to rest upon. When there is an excessive amount of this fat in the orbit, it may cause the eyes to become a little prominent. In wasting diseases, such as tuberculosis or typhoid fever or diseases in which the water is rapidly taken from the tissues (cholera), the eyes may become sunken from shrinkage of this fatty cushion.

The connective-tissue fibres from the inner surface of the periorbita, form complete sheaths for the ocular muscles. Bands of connective tissue from these sheaths, connect the muscles to one another, to the orbit and to the lids. It is from this connective tissue, furthermore, that the tarso-orbital fascia, which joins the orbital margins of the lids to the margins of the orbit, is formed.

Lastly, distinct sheaths for the optic nerves and eyeball are formed from this connective tissue—the sheath or capsule of Bonnet, and the capsule of Tenon. Bonnet's sheath surrounds the optic nerve from its entrance at the optic foramen to the posterior surface of the globe of the eye, where it flares out to surround the posterior portion of the eyeball, extending as far forward as the equator. From the equator forward it is closer applied to the eyeball and is known as the capsule of Tenon. Just in front of the equator it is pierced by the tendons of the oblique muscles, and a little further forward it is pierced by the four tendons of the recti muscles, with which tendons it becomes

blended and is attached to the sclera, a few lines back of the corneal margin. Sheaths are given off from the capsule, to cover the muscles for a short distance in the direction of their origin, from the point where the tendons pierce the capsule. The spaces between Tenon's capsule and the eyeball, and Bonnet's capsule and the eyeball and optic nerve are to be regarded as lymph spaces. They are lined by endothelium, as are other lymph spaces (Schwalbe, Germany, nineteenth century). The eyeball moves in these spaces after the fashion of a ball-and-socket joint. Three rudimentary, non-striated muscles are sometimes found in the connective tissue and fat of the orbit. They are well-developed muscles in some of the higher animals. The lower one is the largest of the three, and is known as the lower palpebral muscle of Müller. It arises in the lower portion of the orbit from connective tissue and periorbita, runs forward and is attached to the orbital border of lower tarsal cartilage. The upper palpebral muscle of Müller, is described under the anatomy of the eyelids. The other and third one is often wanting, being a mere slip of organic muscle fibres.

Blood-Vessels.—The arteries to the orbit are from the ophthalmic, a branch of the internal carotid. The *orbital* group of arteries from the ophthalmic are: Lachrymal, supra-orbital, palpebral, nasal, frontal, anterior, and posterior ethmoidal. The *ocular* group are ciliary arteries—long, short, and anterior, central artery of the retina and muscular branches.

The veins corresponding to these arteries empty their blood into two main trunks, the superior and inferior ophthalmic veins. These converge toward the lower inner angle of the sphenoidal fissure, and usually unite to form one vein before passing out of the orbit through the sphenoidal fissure, to empty into the cavernous sinus. The lower ophthalmic vein, may not join the upper, but may pass out of the orbit through the spheno-maxillary fissure to empty into the pterygoid plexus; or it may pass out of the orbit through the sphenoidal fissure, and empty into the cavernous sinus, independently of the upper ophthalmic vein. The veins of the orbit, are connected anteriorly with the anterior facial vein, especially close with the angular branch of that vein. Consequently, when the venous blood is retarded in

its flow through the posterior part of the orbit, it can pass off anteriorly, and *vice versa*.

NERVES.—The motor nerves to the orbit are: the third, fourth, and sixth. The sensory are: from the first division of the fifth—lachrymal, nasal, and frontal; and from the second division of the fifth—orbital and palpebral branches. The sympathetic branches are from the carotid plexus. The lenticular ganglion, described elsewhere, receives motor, sensory, and sympathetic branches, and the short ciliary branches given off from it possess all three of these qualities.

There are no lymphatics in the orbit.

FUNCTIONS OF THE ORBITS.—The function of the orbits is to furnish protection to the eyeball in its various movements. This is afforded by their deep position and the thick rims which make up their margins.

CHAPTER V.

The Eyeball Considered as a Whole.—Comparison to a *Camera Obscura*.—The Purple of the Retina.—Draper's Theory of the Formation of Images.—Action of the Lenses of the Eye.—Duration of Impressions on the Retina.—Color and Pitch.—Binocular Single Vision.—Erect Vision.—Estimation of Distance.—Average Human Eye Not an Ideal Optical Instrument.

THE GENERAL PHYSIOLOGY OF VISION.

It may be well at this point to bring out the principal facts, so far as at present known of the physiology of vision, by considering the eyeball as a whole. The old comparison of the eyeball to the camera used in taking photographs, is a proper and convenient one. As we have seen in studying its anatomy in detail, it is essentially a hollow sphere, filled with fluids and semi-fluids, having its interior surface darkened by black pigment, and containing a system of lenses by which images can be formed and a screen upon which they may be received. In the front part of the sphere is a diaphragm, the iris, with a movable central opening, to regulate the quantity of light admitted. This certainly is very like the apparatus used in taking a photograph. The purple of the retina discovered by Boll and Kühne, a coloring destroyed by the action of the light, might lead us to make the comparison even more close. We might conclude that the retina is a sensitive plate, placed at the back of the eye, like that which the photographer slips into his camera before taking a picture, and that the sensitive surface of the plate, the sight purple, is worn out by the action of light in forming the images, and constantly renewed again; that the eyeball is not only a camera obscura, but a complete photographic establishment.[1]

Prof. John W. Draper long since claimed for the pigment of the choroid[2] the function of receiving the image. He said: "It

[1] E. T. Ely, Wood's "Household Book of Medicine," vol. ii., p. 235.
[2] "Human Physiology," New York, 1865, p. 392.

is the black pigment which acts as the receiving or optical screen and not the retina."

Draper argues that the thickness of the retina is sufficient, without other evidence, to show that it cannot be the surface on which an image is formed. "Images can only form with precision or sharpness upon an abrupt surface." In albinos, he continues, and in animals in which the black pigment is imperfectly developed the receiving surface is still the choroid. The vision is indistinct, because this surface is so poor a one, because it is so deficient in pigment. The act of vision commences, according to Draper, in a local disturbance of temperature, and this doctrine, he claims, is in perfect harmony with the anatomical structure of the retina, the posterior surface of which is its sensory one, and not the anterior. If the ordinary explanation of the nature of vision is correct, the anterior would be the sensory one. Draper quotes Count Rumford in his argument, who concluded from the examination of a limited number of cases, that all photographic effects are the effects of a high temperature, and he substantiates this view by examinations conducted for a series of years.

Vision according to Draper is a photographic effect, the receiving surface being a mathematical superficies. All objects are therefore definite and sharply defined upon it. If vision took place in the retina as a receiving medium, according to Draper all objects would be indistinct at their edges. Dr. Draper's interesting argument for the pigment layer of the choroid as the real screen on which the image is formed, may be transferred to the retina, if we consider that its last layer is one of pigment. He concludes with the important statement that the sensation of light is purely mental, and that whatever can disturb the nutrition or waste of the retina, will give rise to luminous impressions. He adduces the pressure of the finger on the base of the eye, a blow, the passage of an electric current, as influences that will produce the appearance of light and of colors. "Heat is only one of a multitude of agents that can disturb the retina." Draper like Young, anticipated many an exact demonstration in science, by the discovery of the principle upon which it depended.

Even up to this time, we are not fully assured of the func-

tions of the visual purple, and we cannot carry the comparison too far. The visual purple has not yet been shown as essential to sight, interesting as are the phenomena which have been discovered in connection with it. At one time it was even believed, or hoped, at least, that the murderer's face might be found on the retina, as the window with its panes and sashes were found on the retina of the rabbit beheaded immediately after it has been exposed to the light of mid-day.

The cornea, the aqueous, and the vitreous humor with the crystalline lens, together form a compound convex lens, the refracting surfaces of the eye. The action of convex lenses outside of the eye, finds its exact counterpart in what goes on in the refractive surfaces of the eye.

As is well known, lenses have the power of causing the rays of light which pass through them to converge to a point, or *to*

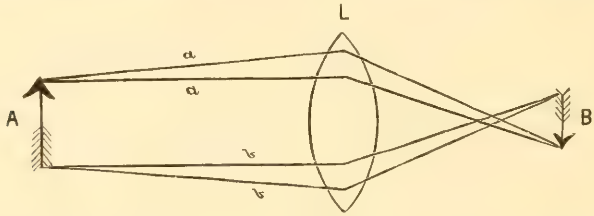

FIG. 35.—L, The lens; A, object; *aa*, *bb*, rays of light from two points of object; B, image.

come to a focus, as it is called. It is on this account that they are able to form *images* of objects. Place a lighted candle a few feet from a white wall, and hold a strong convex lens (one of three or four inches focus) vertically, in a direct line with the flame and between it and the wall. Then move the lens backward and forward in a line with the flame, and a point will be found where a distinct image of the flame will be formed upon the wall. An image can be formed of any luminous object in the same way. The image will be found to be smaller than the object, and upside down. The image is formed because the rays of light coming from every point of the object are made to unite in corresponding points behind the lens, by passing through the latter. The image is inverted because the rays, in passing through the lens, cross each other—that is, those coming from the top of the object go to the bottom of the image, etc. (Fig. 35).

The rays of light which enter the eye from external objects

are converged by its compound lens in exactly the same manner. All that is required to produce a clear image on the screen (or retina) at the back of the eye, is to have the proper relative distances between the object, the lens, and the retina, just as in the case of the candle, the glass lens, and the wall. In the normal eye these conditions are fulfilled in the act of vision. By laying bare the retina in animals, experimenters have seen the inverted images of external objects formed there.

Returning to the experiment with the candle: as soon as the image on the wall is distinct, fix the lens in its position. Then, if the candle-flame is moved—if, for instance, it is carried nearer to the lens—the image on the wall will immediately become blurred. To get a distinct image again under these new conditions, the lens must be moved to another point, or must be replaced by one of different power. In the camera obscura the lens can be moved back and forth, so as to form a clear image, whatever the distance of the object. In the eye, however, the distance between the lens and the retina (the retina here representing the white wall in the experiment) may be said to be unalterable. Hence, as the eye is required to see objects at all distances, it must possess the faculty of changing the strength of its lens accordingly. Without this faculty, the image on the retina could be distinct only within very narrow limits. This power in the eye is that of adjustment or of accommodation. It is required chiefly for vision of objects at short distances. As soon as objects are brought near to the eye, the rays of light

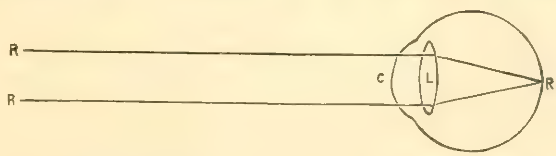

FIG. 36.—*c*, Cornea; L, lens; R, retina; RR, rays of light.

from them become more divergent, so that they cannot be brought to a focus by the lens so quickly.

Fig. 36 represents two rays of light entering the eye from a given point of a distant object.[1] It will be seen that they are united in a point exactly on the retina.

[1] In the ideal eye the distance between the lens and the retina is such that rays of light, which are parallel when they enter the eye, are exactly focused in the

Fig. 37 represents two rays coming from a point of a near object. It will be seen that they are more divergent. Hence, they cannot be brought to a focus so quickly. If not interrupted in their course, they would be united in a point behind the retina,

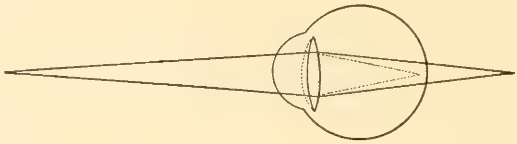

FIG. 37.

as shown in the figure. In order to unite these rays on the retina, the lens must become thicker—that is, its converging power must be increased. This is actually done through the faculty of *accommodation*, and this is what that term means. The change is shown in the figure by the dotted lines. The nearer the object, the more divergent the rays from it, and the thicker must the lens become to keep the focus in the retina. As the object recedes from the eye, the lens must become weaker again, which it does by becoming flatter—less strongly curved. All these changes in the lens are accomplished through the action of the ciliary muscle, which is the muscle of accommodation; and they take place usually without any conscious effort on our part. During the act of accommodation the pupil contracts, so that the diverging rays from the near object are allowed to pass only through the central part of the lens, and thus the image on the retina is more distinct than it would be otherwise.[1] If one looks at his own eye in a mirror, and brings the mirror gradually nearer to his eye, he will see this contraction of the pupil take place.

In white rabbits and other albinos, Magendie was able, by removing the fat and muscles covering the posterior portion of the

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retina. It is found that all rays from distances greater than twenty feet, are so slightly divergent that they may be regarded as practically parallel. Hence, the perfect eye sees objects at all such distances without any use of its faculty of accommodation. This form of eye is ideal and very rare.

[1] Because the spherical aberration of the lens is thus lessened. The lens is so constructed that its density decreases from the centre toward the periphery, and this also tends to lessen its spherical aberration.

eye, to see the image of a flame upon the retina inverted and diminished.[1]

In describing the retina, it was shown that the macula lutea, or yellow spot, was the most sensitive part of it, both as regards light and color, and the part always directed toward the object of sight—*the centre of direct vision*, as it is called.[2]

A single trial will show that, in looking at an object, only a small part of it is seen *distinctly* at one time. The surrounding parts are seen, but they appear blurred. This is because the image of these parts falls on portions outside of this most sensitive point—the macula. Hold the accompanying circle (Fig. 38) about eight inches away, and look at it with one eye, the other being closed. It will be found that the words in the centre and the words in the margin cannot be read *at the same instant*. When the words in the centre can be seen *with perfect clearness*, those in the margin will appear blurred.

FIG. 38.

As a compensation for this limitation of distinct vision, the eyeballs can be rotated by their muscles in every direction, so as to command a very extensive field of view. These movements are so rapid and so habitual, that most persons are not aware of the limitation named. Impressions on the retina have a certain *duration*, which is estimated to be about one-third of a second. Many familiar experiments illustrate this fact. A lighted torch, revolved rapidly before the eye, gives the impression of a continuous circle of fire. In a rapidly revolving wheel, the spokes cannot be distinguished from each other.

[1] Flint, from Magendie, "Physiology of Man," vol. v., 1874, p. 89.

[2] An imaginary straight line, drawn through the refractive centre of the eye, from the yellow spot to the point looked at, is called the *visual line*, or the *visual-axis*. It does not coincide with the optic axis, and must not be confounded with it.

The *color* of light is considered to be analogous to the *pitch* of sound. As the latter is determined by the number of vibrations of the atmosphere which strike the ear in a second, so the former depends on the number of waves of ether which strike the retina in a second. The lowest note of an ordinary musical scale has sixteen vibrations per second; the highest has 20,000 per second. The number of ether-waves which strike the retina *in a second*, to produce the sensation of red (which lies at the bottom, so to speak, of our color-scale), is estimated at 474,439,-680,000,000. The number required to cause the sensation of violet, which lies at the other extreme of our color-perception, is estimated at 699,000,000,000,000 *per second!*

The two eyes move in harmony with each other in such a way, that the macula lutea of each retina is always directed to the point looked at—that is, the two visual lines meet in that point. An idea of these movements, may be gained by watching another look at an object as it is approximated to the eyes. As the object is brought nearer, the eyes are turned in toward each other (or *converged*) more and more, so as to keep the two visual lines always directed to the point looked at, and thereby to cause an image always to fall on each macula.

It thus appears that in ordinary vision with both eyes, there is an inverted image of the object formed at the macula lutea of each retina. By means of the optic nerves, the impressions which these two inverted images make upon the retinæ are conveyed to the brain, and thence results a visual perception, the object appearing to us *single* and *erect*.

If one of the eyes is turned so that its macula lutea is not directed to the same point as that of the other eye, the two retinal images will not be united as usual, and the object will appear doubled. This double vision can very easily be caused if, when looking at an object with both eyes, one of the eyes is made to deviate a little from its proper position by pressing against it with the finger—as by pushing it upward by pressure through the lower lid.

The phenomenon of single, erect vision from the two inverted retinal images has occasioned much discussion. Scientists have given explanations of it which seem plausible enough, but it can be hardly said that the matter is thoroughly understood. In

speaking of the perception of *images* on the retina, it must be remembered that there is no proof that the mind takes cognizance of them *as such*. We can only say that vision is the result of an irritation of the nerves of the special sense of sight, as hearing, smell, and so forth, are due to irritations of other special nerves. Whatever we may know of the formation of images on the retina, and of the changes which they excite there, the perception of these impressions by the brain must still

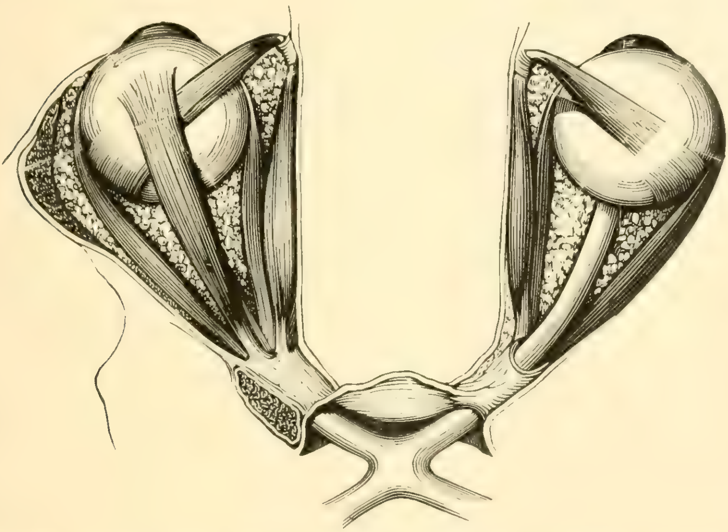


FIG. 39.—DIAGRAM OF THE EYES AS SEEN FROM ABOVE, showing the muscular apparatus by means of which they are directed toward the same object.

seem mysterious to us. Draper believed that the correction of the inverted images was made in the macula.[1] On this subject Helmholtz says:[2] "Our natural consciousness is completely ignorant even of the existence of the retina and of the formation of images; how should it know anything of the position of images formed upon it?"

It is a curious fact that sensations of light and of luminous objects can be excited where no light enters the eye, as by blows upon the eye, and by certain irritations in eyes which are totally blind. In looking at an object near enough to require convergence of the eyes, the image of each eye differs considerably

[1] *Loc. cit.*, p. 397. [2] "Optique Physiologique," Paris, 1867, p. 771.

from that of its fellow. This can be readily seen by looking at a near object, and covering each eye alternately. The right eye will see more of the right side of the object, and the left eye more of the left side. It is the combination of these two different impressions that gives us our ideas of *solidity* and *depth* —what is called the *stereoscopic effect.* Otherwise, objects would appear unduly flat to us. The muscular efforts required to direct both visual lines toward an object, and to see it distinctly, are the chief factors from which we unconsciously estimate the *distance* of an object. This is largely a matter of education and experience. If only one eye is used, it will be found much more difficult to judge of distance correctly. The average human eye, that is to say, the eyes of the most of the human race, has many deviations from a perfectly constructed optical instrument. But, as thus found, it is well adapted for vision, and is even, although not an ideal apparatus, one of the most wonderful and beautiful parts of the human organism.

PART II.

THE RELATIVE FREQUENCY OF DIFFERENT DISEASES OF THE EYE, METHODS OF EXAMINATION, THERAPEUTICS AND SURGERY OF THE EYE.

CHAPTER VI.

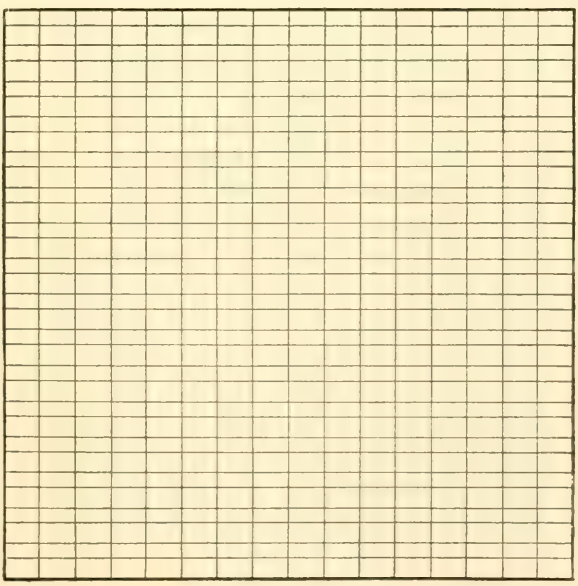
Relative Frequency of the Various Affections of the Eye.—Table prepared from Private Practice.—Table from American Ophthalmic Clinics.—Cohn's Tables.—A Combination of Them.

I HAVE thought that an instructive chapter might be found in a series of tables, illustrating the frequency of the various diseases of the eye. I have, therefore, caused to be compiled from the records of my private practice, and from the reports of various ophthalmic institutions, the following tables:

I.

Table showing the various forms of disease of the eye as seen in cases observed in various ophthalmic institutions:

Diagram illustrating the Comparative Occurrence of the Principal Affections of the Eye.



	Cases.	Per Cent.
Conjunctiva	184,164	30.2900
Cornea	126,927	20.8866
Refraction and accommodation	87,870	14.4522
Lids	55,400	9.1101
Unclassified	30,216	4.9697
Lens	25,041	4.1185
Muscles & nerves	22,613	3.7192
Iris	21,843	3.5925
Lachrymal app.	14,678	2.4108
Optic nerve and retina	12,515	2.0583
Ciliary body and choroid	9,411	1.5478
Globe	8,183	1.3458
Amblyopia	2,862	0.4707
Sclera	2,722	0.4477
Vitreous	2,370	0.3898
Orbit	1,147	0.1886
Total	608,002	100.00

[Table constructed on a ratio of 2 per cent to each ordinate.]

The cases for the above table were treated in the following institutions, as shown by their annual reports:

New York Eye and Ear Infirmary (23 years)	224,972
Manhattan Eye and Ear Hospital (23 years)	94,064
New York Ophthalmic and Aural Institute (10 years)	56,610
Massachusetts Charitable Eye and Ear Infirmary (10 years)	95,466
Brooklyn Eye and Ear Infirmary (23 years)	70,568
Presbyterian Eye, Ear and Throat Charitable Hospital (Balt.) (12 yrs.)	53,423
Illinois Charitable Eye and Ear Infirmary (2 years)	9,933
Maine Eye and Ear Infirmary	2,966
	608,002

Comparing this table based on 608,002 cases, collected from eight institutions in the United States from 1870 till 1893, to the table[1] of Cohn based on nearly 300,000 (297,326) cases, collected from 67 European institutions from 1862 to 1875, the almost exact coincidence of the results is remarkable.

	Author's Table. Per Cent.	Cohn's Table. Per Cent.
Conjunctiva	30.2900	30.
Cornea	20.8866	21.
Refraction and accommodation	14.4522	12.
Lids	9.1101	9.
Unclassified	4.9697	1.50
Lens	4.1185	6.
Muscles and nerves	3.7192	3.20
Iris, Choroid and ciliary body, Glaucoma	5.1403	7.
Lachrymal apparatus	2.4108	2.
Optic nerve, retina, Amblyopia	2.5290	5.
Globe	1.3458	2.
Sclera	0.4477	0.4
Vitreous	0 3898	0.7
Orbit	0.1886	0.2
	100.00	100.00

It will be noticed from this comparison, that in diseases of the conjunctiva, cornea, lids, muscles and nerves, lachrymal apparatus, sclera, vitreous, and orbit, the difference in each instance is less than one-half of one per cent. The relative higher per cent of refractive and accommodative cases in the Ameri-

[1] Eulenburg's "Real-Encyclopädie der Gesammten Heilkunde;" 2. Art.-Bio., p. 313.

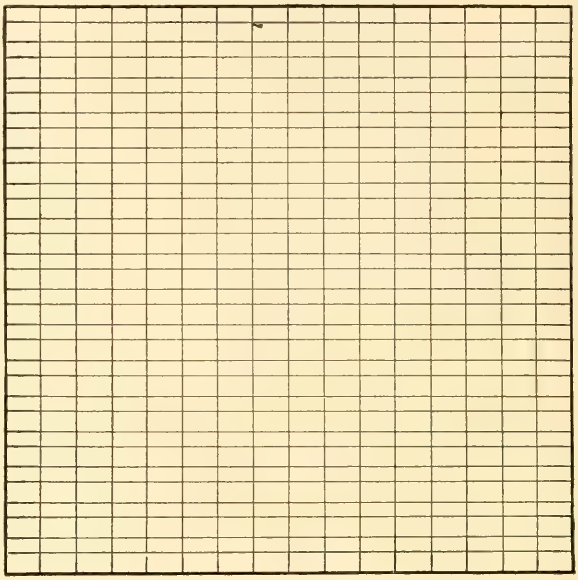
can table (14.4522 per cent) as compared to the European table (12 per cent) is significant in showing that we in America have a higher per cent of such cases, or that we by more thorough examination of the refractive condition of the eye, find a greater number of such cases. If this table had been taken from cases treated in the last four or five years in the American institutions the difference would have been greater still. To illustrate: in the year 1870, the New York Eye and Ear Infirmary treated within its walls 7,387 eye patients, 186 of which were cases of refraction, or 2.5 per cent. For the year 1892, there were treated in this same institution 15,381 eye patients, 2,125 of which were errors of refraction, 13.8 per cent, the relative increase of refractive cases being more than five-fold. And for the year 1892 at the Manhattan Eye and Ear Hospital, the per cent of refractive cases was much greater than that at the Infirmary: 9,286 eye patients were treated, 2,910 of which were refractive cases, or 31.3 per cent. No doubt the per cent of refractive cases has increased relatively in the European institutions, but nothing like so great, I suspect, as in America, where we now pay so much attention to errors of refraction and accommodation. School-teachers, dressmakers, seamstresses, milliners, type-writers, and clerks, who are unable to pay a fee for medical advice, form a very large proportion of those coming to the New York ophthalmic institutions for advice about glasses. They are extremely critical, not only about seeing well, but they wish to see the best possible.

A later table from European sources would be interesting for comparison, but we have not the means of furnishing it at this time. By combining the table given here and that of Cohn, making a grand total of almost a million (905,328) cases, the table illustrating the relative frequency of the different affections of the eye is as given on the preceding page.

The value of such a series of tables as this is modified by many circumstances that will be at once evident to the reader. They do not actually show the exact proportion of certain conditions, in the entire community, for an illiterate person, having no need of close work with his eyes, will not consult an oculist on account of an error of refraction, nor will he even come to an eye clinic on account of his sight, until it is so much

Diagram illustrating the Comparative Occurrence of the Principal Affections of the Eye.

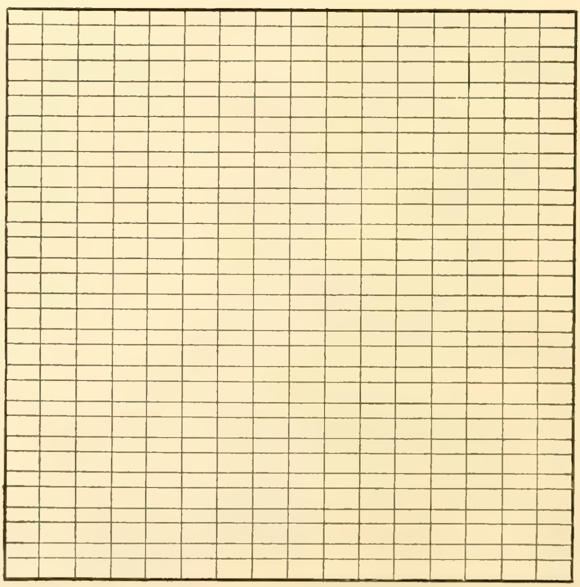
Cases.	Per Cent.
Conjunctiva	30.1450
Cornea	20.9433
Refraction and accommodation	13.2261
Lids	9.0550
Iris, choroid and ciliary body	6.0701
Lens	5.0592
Retina, optic nerve and amblyopia	3.7645
Muscles and nerves	3.4596
Unclassified	3.2348
Lachrymal apparatus	2.2054
Globe	1.6729
Vitreous	0.5449
Sclera	0.4238
Orbit	0.1943
905,328	100.00



[Table constructed on a ratio of 2 per cent to each ordinate.]

Diagram illustrating the Relative Frequency of the Different Affections of the Eye [Private Practice].

Affections.		Per Cent.
Refraction and accommodation	8,543	62.2304
Conjunctiva	1,055	7.6850
Cornea	833	6.0678
Optic nerve and retina	693	5.0480
Lids	577	4.2030
Lens	576	4.1958
Muscles and nerves	522	3.8424
Ciliary body and choroid	270	1.9667
Lachrymal app.	219	1.5952
Iris	218	1.5879
Globe	105	0.7648
Vitreous	84	0.6118
Sclerotic	21	0.1529
Unclassified	7	0.0509
Orbit	5	0.0364
	13,728	100.00



[Table constructed on a ratio of 4 per cent to each ordinate.]

impaired that he can no longer earn his living or get about. On the contrary, intelligent and educated persons, in exacting occupations, or who are close observers, will come at the first notice of even a slight defect. But the tables, at least, give an idea of the great importance of a good understanding of errors of refraction and accommodation, since such a vast number of persons seek relief on account of them. Then again practitioners in the smaller cities and towns, where the general practitioners sometimes decline to treat even the most common and simple inflammatory affections, will see a larger proportion of inflammatory cases. In New York City, a large proportion of general practitioners treat such cases in private practice. Other circumstances might be mentioned, which would show that I make no claim to exact proportions of the frequency of diseases of the eye, by these tables, yet I think they have a distinctive value, which will cause them to be appreciated by my readers.

The effect of the civilization of the latter half of the nineteenth century upon the human eye is graphically portrayed in the percentage of cases for which glasses are prescribed. The inventions of the ophthalmoscope and the ophthalmometer, here celebrate their triumph.

CHAPTER VII.

THE EXAMINATION OF THE EYE.

Exactness with which the Human Eye may be Examined.—The Eyelids, Color, Mobility, Thickness.—Method of Everting the Upper Lid.—Examination of the Lachrymal Sac and the Puncta.—Artificial Illumination.—Oblique Illumination.—Elevators.—Tests for Vision.—Jaeger's Test Types.—Snellen's Test Types.—Some Patients Obliged to Learn to See.—Javal's Optometer.—Tests of the Light Sense.—The Ophthalmoscope.—History of its Invention.—Method of Use.—Principle upon which its Use Depends.—The Direct Method.—The Inverted Method.—The Picture Seen.—Examination of the Refraction.

THE human eye, in a state of health or disease, may be examined as to its condition, with more exactness, and certainty, than any other organ of the body, except, possibly, the skin. The eyelids and their lining, the conjunctiva, the cornea, the sclera, the iris, and the pupil have always been easily examined by the unassisted eye. By the use of strong light and a magnifying glass, these parts could be still more closely studied. But until the invention of the ophthalmoscope, the space behind the pupil remained almost entirely concealed. It is true that marked changes in the crystalline lens could be detected before this, but when illuminated by the ophthalmoscopic mirror, the pupil, the retina, the choroid, the vitreous humor, and the crystalline lens, became as open to exact study as the common integument. The trained observer has means now at his command, that enable him to thoroughly examine the human eye, and to leave comparatively little of the morbid changes, or normal appearances of its structure, a matter of conjecture or inference. I shall endeavor in this chapter to show the steps in such an examination, as practised at the present day.

THE LIDS.

These should be carefully looked at, unless it is obvious, at the first glance, that there is no change in them from the nor-

mal condition. The color, mobility, thickness, as compared with healthy lids, should be noted. The condition of the eyelashes, whether or not they are present in full number, whether there is any secretion at their roots, should be observed. Then also the mouths of the Meibomian glands, at the edge of the lids, in the so-called *tarsal cartilages*, should be examined. Having made this general survey with the aid of magnifying glasses, if the observer be presbyopic and not myopic, the upper lid should be turned over and examined. This latter is a little manipulation which may cause the beginner in the treatment of diseases of the eye, not a little trouble. It will be well for him, in the very outset of his studies, to practise this method of examination until he is very familiar with it, and is able at once to turn over the lid, and carefully examine the mucous membrane with which it is lined.

The inner surface of the lower lid is easily exposed, by pulling the skin of the lid downward with the tip of one finger, while the patient rolls the eye upward. *To evert the upper lid*, the patient must direct his eyes—not his head—downward; the surgeon then grasps the central eyelashes between the thumb and finger of the left hand, and pulls the lid a little downward and away from the globe; he then places the tip of the thumb of the right hand upon the skin of the lid, well back from its edge, *so as to be beyond the upper limit of the tarsal cartilage.* He then presses a little downward, with the thumb of the right hand, and turns the edge of the lid upward by means of the lashes held with the left hand. The thumb of the right hand may then be removed, and the lid held in its everted position by the left hand, while it is examined, or while the applications are being made to it. After a little practice, it will be found easy to evert the upper lid in this way. Sometimes it will be found easier to turn it over a probe or pencil, than over the thumb. In small children, where the lids are swollen and congested by crying or other causes, simply separating them with the thumb and finger of one hand will often cause their inner surfaces to be well everted and exposed. The next step will be to examine the lachrymal sac and the puncta. Pressure upon the former, and minute observation of the latter, will be sufficient for this purpose. In a normal condition, no mucus or tears will come

out of the punctum, even when the thumb is firmly pressed upon the lachrymal sac.

The lids, conjunctiva, and lachrymal passages having been thoroughly looked at, the cornea should next engage the attention of the observer. This is an important and sometimes difficult part of the examination. Ordinary daylight, even when the examiner's eyes are young and sound, is not always sufficient to determine whether or not there is any impairment of the transparency of this homogeneous structure. Unless artificial light is used, minute opacities or foreign bodies may escape observation. The best source of artificial illumination is

FIG. 40.—OBLIQUE ILLUMINATION.

electric light. This is the whitest and least trying to the eyes of all artificial light. An incandescent electric lamp of the strength of sixteen candles is sufficient illumination. The glass of the lamp should be what is termed ground glass.

Next in order of excellence to electric light, is gas-light in an Argand burner, or the light of a good oil lamp. In a case of

emergency, a candle becomes a good source of illumination, and when used in the lamp here pictured, even an excellent one.

This lamp has many advantages, in its cheapness, portability, and efficiency. Dr. Loring's head mirror and lens, are very useful, when no assistant is at hand, in removing foreign bodies, and cauterizing ulcers of the cornea.

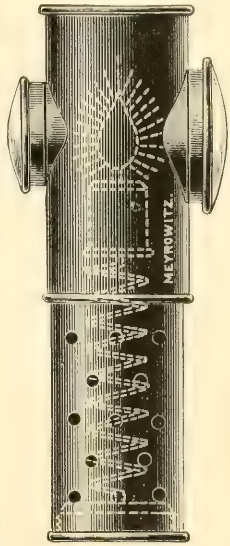


Fig. 41.—Lantern Containing a Candle. (Priestly Smith.)

OBLIQUE ILLUMINATION.

Oblique illumination is very important for examining the cornea, anterior chamber, iris, pupil, lens, and even the most anterior part of the vitreous, showing minute details which escape the naked eye. To produce it, daylight, electric, gas or lamp light are focused upon the eye, with a $2\frac{1}{2}$-inch (say, 16 diopters) convex lens. If a lamp is used it should be to one side, and somewhat in front of the eye examined, on a level with it, and about two feet off. The observer's eye should be in the path of the reflected rays. By moving the lens, the cone of light may be made to traverse all parts of the cornea. The appearances can be magnified by look-

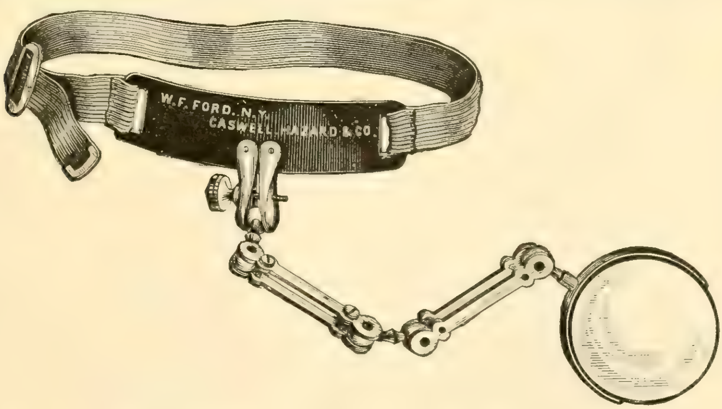


Fig. 42.—Loring's Head Mirror. (From Vol. I., "Text-Book of Ophthalmoscopy.")

ing through another strong convex lens, held directly in front of the examined eye. The cornea having been examined, and

with it the iris, having noted any loss of transparency in the former, any changes in the color, or impairment of the mobility of the iris, we are ready for an examination of the interior of the eye.

In the case of young children or infants with any affection of the conjunctiva or cornea, producing photophobia, or even in adults, or when there is very great swelling of the lids, it may often become necessary to use an instrument called an elevator, for the purpose of opening the eye. Young children should be carefully held on the lap of the attendant, by the feet, while the head is between the knees of the surgeon. The greatest care

FIG. 43.—ELEVATOR.

FIG. 44.—METHOD OF EXAMINING AN INFANT'S EYE.

should be taken in the placing of the elevator under the upper lid, for, if the cornea be ulcerated and undue pressure be excited, it may be ruptured and the lens evacuated.

It goes without saying that in quite a proportion of cases, usually those of an external inflammatory nature, such, for example, as acute conjunctivitis, foreign bodies on the cornea, ulcers of the cornea, of the lids, and so forth, the examination may end here.

VISUAL TESTS.

But in the majority of patients, it will be important to examine the visual power, and this is properly the next step. It is very convenient, if the consulting-room be so situated that a space of twenty feet can be secured for an examination of the visual power. It is also important to secure a uniform degree of illumination. The latter can only be had by artificial light, for in many climates the occurrence of cloudy and rainy days so changes the illumination, that the tests are unreliable. On the other hand, the practitioner may be warned against too great detail in all this. What is to be found out is the patient's average vision, under ordinary conditions, as compared with the average vision of ordinary people. Whether a person sees $\frac{20}{20}+$ or $\frac{20}{20}-$[1] is not usually an important matter with good vision. But it is an important inquiry, as to whether his vision is $\frac{20}{70}$ or $\frac{20}{40}$ for example. It is well for the young practitioner, in the first years of his practice, to be very punctilious in every detail, until finally his faithful routine will develop a knack, or aptitude, that will enable him to come to correct conclusions without all the somewhat toilsome procedures necessary to an exhaustive examination. The close observing traveller will forget much that he sees, but his minute observations will have the effect of giving him, when all else has

Jaeger's Test-Types.

No. 1.

When, in the course of human events, it becomes necessary for one people to dissolve the political bands which have connected them with another, and to assume, among the powers of the earth, the separate and equal situation to which the laws of nature, and of nature's God entitle them, a decent respect to the opinions of mankind requires that they should declare the causes which impel them to the separation.

We hold these truths to be self-evident—that all men are created equal; that they are endowed by their Creator with certain inalienable rights; that among these are life, liberty, and the pursuit of happiness. That, to secure these rights, governments are instituted among men, deriving their just powers from the consent of the governed; that, whenever any form of government becomes destructive of these

No. 2.

ends, it is the right of the people to alter or abolish it, and to institute a new government, laying its foundations on such principles, and organizing its powers in such form, as to them shall seem most likely to effect their safety and happiness. Prudence, indeed, will dictate that governments long establised should not be changed for light and transient causes; and, accordingly, all experience hath shown that mankind are more disposed to suffer, while evils are sufferable, than to right themselves by abolishing the forms to which they are accustomed. But when a long train of abuses and usurpations, pursuing invariably the same object, evinces a design to reduce them under absolute despotism, it is their right, it is their duty, to throw off such government, and to provide new guards for their future security. Such has been the patient sufferance of these Colonies, and such is now the necessity which constrains them to alter their former

faded out, a thorough knowledge of the essential and general aspects of the country through which he has journeyed. This

[1] By $\frac{20}{20}-$ it is meant that some but not all of the letters of $\frac{20}{20}$ are seen, and by $\frac{20}{20}+$ that more than all the letters of $\frac{20}{20}$ can be made out.

principle holds good in observations in the field of medicine and surgery.

There were no accurate tests for vision until the ophthalmoscope was invented, but they very soon followed. In 1854 Edward Jaeger in Vienna and Alfred Smee, in London, published a set of test letters. These consisted of a series of graded type, ranging from the smallest that are cast, to very large letters, such as are used in handbills.

For the purpose of determining near vision, the capacity to read, to determine the near point and so forth, these have never been superseded. They are of themselves, a great advance in the means of exactly determining what a patient can do with his eyes, yet by their use alone we cannot exactly determine the visual power. It is a cardinal principle in the examination of the functions of the eye, that the visual power shall be determined at a distance corresponding to infinity, or the point from which the rays of light entering the eye are parallel.

The normal visual angle was found by the following experiment. Two black objects on a white ground were used as the tests. It was observed that they could be seen as distinctly separate objects, when separated by a space subtending an angle of $1'$ with the eye. This limit is not the lowest in all cases, but sufficiently so to form a basis for a scale on which to test visual acuity. An eye that has this power or degree of discrimination, is said to have full visual power. If, however, the smallest angle be $2'$, $3'$, $4'$, the visual acuity may be expressed by the fractions $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$.

Instead of feet, there are tables having metres, the smallest letters being seen at 6 metres, the others at 9, 12, 18, 24, 36, and 60 metres respectively. When a room is too small to admit of 20 feet, or 6 metres, as a testing space, an additional line of letters seen at 15 feet should be added.

FIG. 45.—SNELLEN'S TYPES.

The next step in the examination of the visual power is due to Dr. H. Snellen, of Utrecht, in Holland, and his methods are, essentially, now everywhere followed. Snellen's types were pub-

lished in 1868. They were founded upon the principle of determining the smallest angle in which the form of a given object may be accurately seen at 20 feet distant. Snellen's tests are large Latin letters, inclosed in a quadrangle. The height and breadth of these letters are, as far as possible, five times that of each of the small quadrangles of which each letter is formed. The numbers above them, CC., C., LXX., LXXX., XX., indicate the distance in Parisian feet (a Parisian foot equals 324.01 mm.) at which these letters can be seen at an angle of 5°. The visual power is expressed by the formula, V equals the distance the letters should be seen, divided by the distance at which they are actually seen. For example, if a patient sees letters only 20

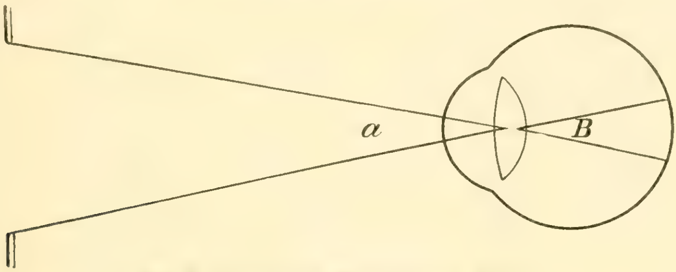


FIG. 46.—DIAGRAM OF VISUAL ANGLE. (Berry.)

feet, that are seen by a subject with normal eyes 100 feet, the vision of that patient is $\frac{20}{200}$. If he sees letters that should be seen at 40 feet at 20 feet only, his vision is expressed by the fraction $V=\frac{20}{40}$, and so forth.

Javal, of Paris, has a set of letters, upon a porcelain tablet, which are reflected by a mirror, into which the patient looks. Beneath this is an optometer which is shown in front of the eye of the person being examined. This method enables an examiner to use a small room with a range of only ten feet, for the mirror doubles the distance. I have used the optometer of Javal for the determination of what glass is required, more or less, for some years, but I generally employ the correcting glasses from the trial case, holding them in the hand. Yet the instrument has many advantages, chief of which is the ability to change the glass held before the patient's eye, with great rapidity, and, at the same time, to keep it steady.

Some patients are obliged to learn to see. In other words, so

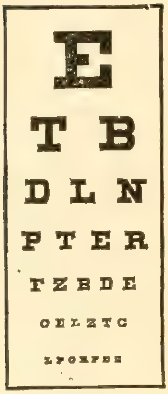


Fig. 47.

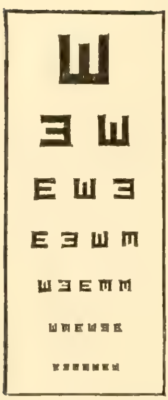


Fig. 49.—Tests for Those who have not Learned to Read.

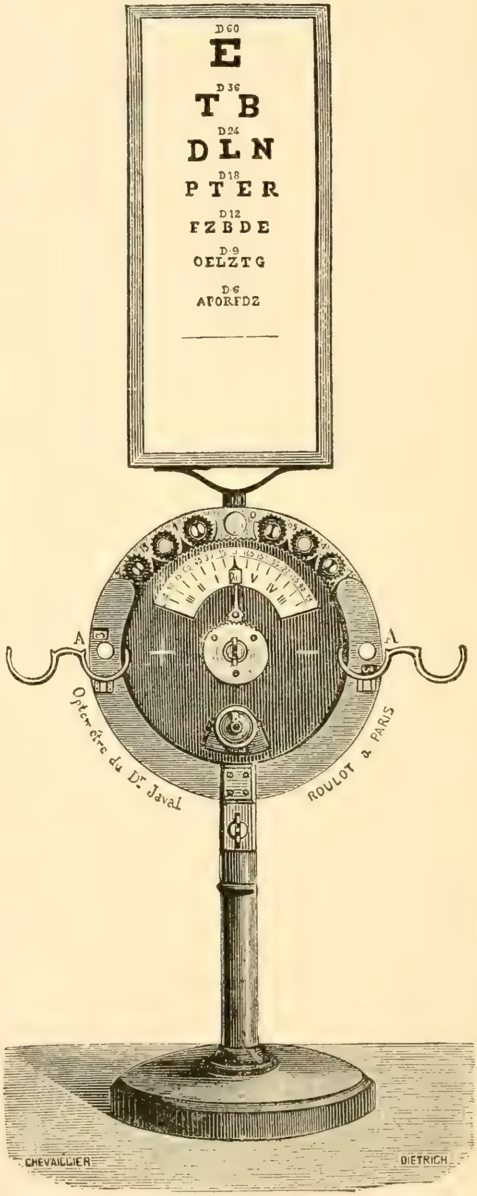


Fig. 48.—Javal's Optometer, with Test Letters to be Reflected in Mirror.

simple a thing as picking out test letters requires practice (Pomeroy, Schweigger). A hasty examination of the visual power of a patient, who has never before tried to read test letters, may cause grave errors. Without any change in the eyes, a second examination of such patients shows, that they have learned to see letters which they declared they were unable to on the first examination. Of course this state of things occurs chiefly, if not entirely, among the careless and stupid, but even intelligent and timid persons need to be proceeded with slowly and carefully, if we wish to determine their actual visual power. We shall then be on our guard lest slight improvements, say from $\frac{20}{30}$ to $\frac{20}{20}$, or $\frac{20}{20}$ to $\frac{20}{15}$, may not be due entirely to practice in a new art, rather than to actual improvement in vision. The oculist should be provided with several cards with different letters arranged upon them, and they should not be left exposed to the gaze of the patient, when not occupied with them, for there is always a class of patients ready to cheat themselves, by seeming to have more sight than they really possess. School children have a great facility for remembering letters that they have seen even but once. Even those who are nearly blind, who can perhaps only tell light from darkness, will sometimes deceive themselves by holding up their own hands before their eyes, and declaring they can see them, when in reality they only see a hand because they know it is there.

THE LIGHT SENSE.

The tests for the perception of colors will be treated of under Color Blindness, and in the discussion of toxic amblyopia. There are certain tests as to sharpness of perception of light for which apparatuses are used, photometers with which the degree of illumination required to make an object visible, is measured. Foerster's photometer, consists of a rectangular box a foot long, a little less than a foot in breadth and height, blackened inside, and fixed

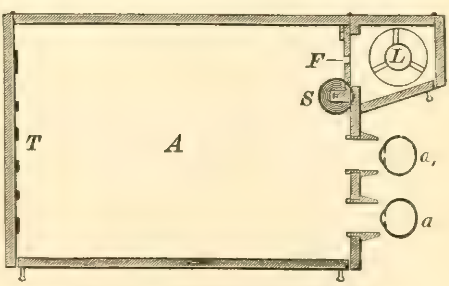


FIG. 50.—FOERSTER'S PHOTOMETER.

to a stand. There are two apertures, *a a*, extending into short projecting tubes, for the eyes to look through. The interior of the box is illuminated by a candle, *L*, kept always at the same height by a spring, and placed at a short distance from the hole in the box. The quantity of light entering the box is regulated by a diaphragm. If the area of this diaphragm be known, the corresponding degree of illumination may be calculated. A couple of squares of white paper of about one inch in size, and placed about one inch apart, *T*, are the objects placed in the box to be recognized. Practically, the estimation of the light sense is very seldom of importance. When it is, it may be determined by tests that will suggest themselves to any observer, a comparison being made with a person known to have a normal light sense and excellent vision. A set of test types, gray letters on a gray background (Bjerrum) has been arranged for testing the light sense. The contrast between the letters and background is of course almost *nil*, while that of those usually employed, black on white, is very great.

OPHTHALMOSCOPIC EXAMINATION.

If there is no diseased condition in the external parts of the eye, and the vision be defective, the next step will be to take up the ophthalmoscope. If, however, the vision be $\frac{20}{20}$ or $\frac{20}{30}+$ even, it will be better to make an examination with the ophthalmometer before going on to the ophthalmoscope, for the reasons which will be fully explained in the course of this chapter, and which will be amply verified in actual practice.

The history of the invention of the ophthalmoscope, important and interesting as it is, is now a twice-told tale. In this volume only a meagre account will be found, as we are here chiefly interested in the method of its employment, and the best one to be used. The ophthalmoscope, as invented by Helmholtz in 1851, is seldom or never used, but the principle upon which its use depends remains the same, and all the various instruments that have been suggested, since the original invention which constituted the Helmholtz instrument, are the same in principle. To that illustrious scientist will ever belong the undying renown, resulting from the invention of a practical method of

clearly examining the interior of the human eye. Yet, like all great inventions, the way had been prepared for it. The invention of the ophthalmoscope, was made possible by the observations of those who had discovered that the pupil could be made the channel of flooding the choroid, and retina, and optic nerve with light, which would be reflected as an image of these parts.

From the earliest times the illumination of the eyes of certain animals, especially those of the cat, had been observed. This was ascribed to a spontaneous development of light in the eye. In 1810, this generally accepted view was denied by Prevost, Rudolphe, and Gruthuisen.[1] The first-named writer showed, that the illumination of the eye never appeared in a perfectly dark room, and that it was to be regarded merely as a reflection of light that had actually entered the eye. Rudolphe, showed that the eye must always be looked at in a certain direction to get this reflex. The observations of subsequent writers proceeded step by step, until Brücke, 1844–45, and Cuming, 1846, had adequately explained the conditions necessary for the illumination of the eye. Although Helmholtz invented an instrument which enabled the observer to accurately examine the retina, in 1851, this discovery was hardly known beyond Germany, until 1854, and only in the capital of that country. In New York City in 1860 it was in the hands of but very few young men. The late Dr. E. Williams, of Cincinnati, was the first in the United States, to introduce the instrument to the knowledge of the profession in this country and England in 1854. The late Dr. Edward G. Loring[2] presented in 1869 an ophthalmoscope for measuring the refraction of the eye, as well as for studying its diseases, which is, with his own and one other modification perhaps, the best of all its successors and imitators for the former purpose.

Professor Helmholtz lately made a visit to this country, and in a public lecture described the invention of the ophthalmoscope.[3] He enumerates the facts known by scientific men in 1847, when he began to search for the ophthalmoscope, as follows:

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[1] "Der Augenspiegel," Zander, 1862.

[2] Transactions American Ophthalmological Society, 1869.

[3] Medical Record, Dec. 16th, 1893.

" I think that no physiologist doubted, until the end of the last century, that the eyes of cats, dogs, oxen, and other mammals, and of birds, developed light of their own which shone forth at night. It seemed to them to be the same process as was observed in the luminosity of insects in the water, and so forth.

" Prevost discovered, at the beginning of this century, that the eyes of mammals which appeared luminous possessed a peculiar anatomical structure, that is, what by anatomists is called the tapetum, situated on the background of the eye. This tapetum has a very resplendent surface, is composed of a peculiar kind of very fine fibres, of very regular thickness, which throw off colors like a layer of thin plates, as was discovered by Newton long ago. This light shone forth from the eye of the dissected animal just as it did during life, so that it became very probable that the light of the living eye, was really not light originally produced by any influence of the nervous system on this organ, but that it was reflected light. At first, however, physiologists who had to speak of these things were rather at a loss to explain how the light could get into the living eye. I must remark that the intensity of the light coming back from such a luminous eye is often very surprising. Even if there is no great amount of light in the neighborhood of the animal, the observer can sometimes see the eyes of the animal luminous in a very high degree.

" From the time of Prevost, say about 1810, at least, doubt awoke as to whether this was not only reflected exterior light. Professor Brücke, of Vienna, made microscopical examinations of the tapetum and its relations to the retina, and endeavored to show that the animal having such a tapetum could get a stronger luminous impression from its retina, than another without the tapetum. He said that if there is a tapetum, and the light is reflected from the background of the eye, through the pupil and back, then the light possesses twice its original luminosity. About 1846 the English oculist, Dr. William Cuming, discovered that the experiment which had succeeded on the luminous eyes of mammalia could also be performed on the living human eye, and everybody's eyes could be made luminous. It is an entertaining experiment in a social gathering, and students have applied it to frighten young ladies. The experiment is very simple. An animal or human being is put in a dark room, a light is placed at some distance in the background. The eye of the observer is nearly in a direct line between the two. The rays of the light pass alongside the head of the observer into the eye of the observed, are reflected back in the direction from which they proceeded, making the observed eye appear very luminous

to the observer. The effect is very curious, giving the impression of seeing a spirit or any other supernatural phenomenon. This experiment was first made by Cuming, and afterward, independently, by Brücke.

"Such were the facts known by scientific men in 1847, when I began to search for the ophthalmoscope. Brücke knew, that the nearer the eye of the observer was to the line of light passing to the eye of the observed, the more luminous would the observed eye appear. But nothing had been seen of the interior structure, of the seemingly luminous eye, the impression given being only that of a diffuse appearance of light covering the whole pupil.

"In my lectures I had to give an account of these experiments, and to try to give an explanation of the phenomena. I was obliged, therefore, to seek for an explanation myself, and I may say that it was not difficult to find—at least for a man who had occupied his time with reading physics and chemistry, and in making experiments, as far as his scanty means would allow. Being acquainted with the principles of optics as far as they were then known, I proceeded to analyze the course of the rays of light in the experiment just alluded to, and thus reached an explanation of the phenomena, the correctness of which was afterward confirmed by the ophthalmoscope."

Helmholtz pointed out the fact, that although certain parts of the eye must absorb most of the light which entered it, others,

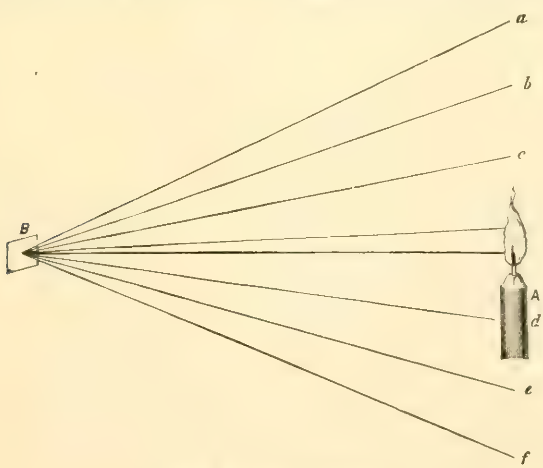

FIG. 51.—(After Loring.)

especially the optic nerve, must reflect it, and that there ought to be some evidence of the reflection of light from the back of the eye,

through the pupil, even if the quantity of light was not enough to permit us to see the back part of the eye in detail. But, as everybody knows, notwithstanding this fact, the pupil is black in the broadest daylight. Helmholtz showed, furthermore, that the blackness of the pupil depended upon the optical law: that the rays of light leaving the eye must return in the same direction in which they entered it, that is, in the direction of the source of illumination. This may be illustrated by Fig. 51. Let *A* be a candle and *B* any small object. Rays coming from the candle would strike the object *B* and be reflected from it by irregular reflection in all directions, and the object would be visible by means of these reflected rays to observers situated at different places as, for example, at *a*, *b*, *c*, *d*, *e*, *f*, the lines returning to which may be supposed to repre-

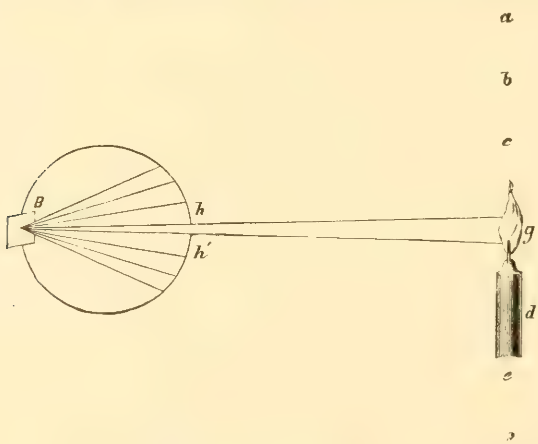

FIG. 52.—(After Loring.)

sent the rays diverging from a single point of the object *B*. If this object be surrounded, as in Fig. 52, by a spherical screen in such a way that, starting from the point *h*, we pass round behind the object, and so on till we stop just short of completing the circle at *h′*; this would cut off all the rays incident and reflected, except those which enter and emerge through the narrow opening between *h* and *h′* in the direction of the source of light; consequently, as the eye situated at the points *a*, *b*, *c*, *d*, etc., does not receive any of these return rays, the object will not be seen, and the aperture through which the rays return will necessarily appear black. In order to get a view of the object, we must put our eye in the course of the returning rays, and here is a dilemma, for, if we place our eye at *g*, that is, behind the candle; this latter cuts off the returning rays, be-

cause the flame is not transparent, and if we place our eye in front of the candle, then our head immediately cuts off the rays coming from the candle, consequently, none can enter the supposed sphere, and none, therefore, return. This is a sufficiently exact representation of the conditions of the eye to warrant us in asserting that what takes place in one case will also occur in the other. We have only to add a dioptric system to make the conditions practically the same. The dioptric system of the eye has no effect upon the general direction in which the rays leave the eye. These must leave it in the direction opposite to that in which they entered it, or toward the source of the illumination. Although the dioptric system does not affect the general direction of the rays of light, it does affect the amount of their convergence or divergence. This can be seen by the following diagram: Let *A* (Fig. 53) be an illuminated point on the fundus of the normal eye, *B*. Rays issuing from this point will issue from the pupil. If it were not for the lens the external rays would proceed in

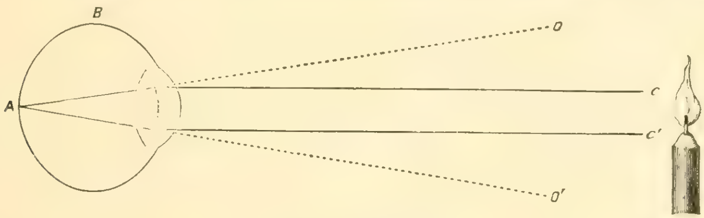

FIG. 53.—(After Loring.)

the direction *AO* and *AO'*, and an observer's eye at either of these places would receive such rays. Meeting, however, the lens these rays are rendered more convergent and bent in the direction *C* and *C'*. The observer will be obliged to move his head to this point to get the reflex, and the more he moved his head toward the median line, the more apt he would be to cut off the entering rays.

Loring[1] illustrates the preceding principle by a French model of the eye, such as is employed for teaching the use of the ophthalmoscope. If a candle is placed before this, the pupil appears black, no matter how near or how far off the lamp is. But if we could bore a hole in the flame at *G*, so as to make a vacant space through which the rays might pass, we should then, if we placed our eye at *G*, be in the track of the rays returning in the direction *HG*. This is illustrated in Fig. 54, which represents the candle and model of the eye a foot or two in front of it. A metal tube is passed through the

[1] "Text-Book of Ophthalmoscopy," Part I., p. 226, from which cuts from Fig. 51 to Fig. 54 inclusive are taken, and Dr. Loring's account of the phenomena used as the basis of the text.

centre of the flame, and is held in its position by a wire twisted around the candle. This makes a perforation through the centre of

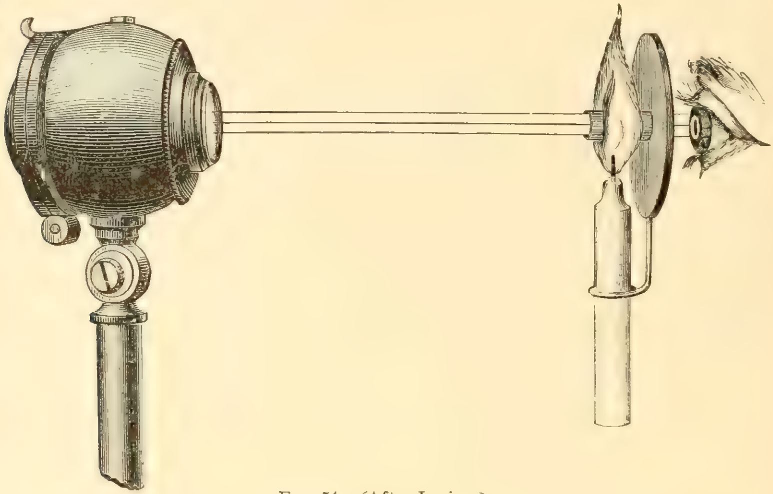

FIG. 54.—(After Loring.)

the flame, and the rays of light returning to it pass through the tube and make themselves visible to the eye placed in their path.

Helmholtz's problem, as has been intimated, was then but a single step from this, "which accident," as Loring says, "might have stumbled upon at any moment if genius, with its unerring instincts and irrefutable methods, had not anticipated it and completely solved the whole problem." The source of illumination is placed at the *side* instead of the front, and the angle of incidence being equal to the angle of reflection, it was possible for the observer to see this image by placing a plane mirror, which changed the direction of the emergent rays, in front of the eye.

Several years before the ophthalmoscope was discovered, after hearing Professor Brücke's lecture, one of his students actually performed this experiment in the anteroom of the University of Vienna, having seen a friend's eye illuminated as he was sitting by a lamp. Helmholtz arranged matters, by using a source of illumination about one foot away from an observation eye, and a mirror consisting of three plates of plane glass placed at a proper inclination. The rays of light diverging from the illuminated point, and striking on the plane mirror, were reflected just as they were received, the only difference being that their direction is changed. They strike the cornea, and the eye being normal, or nearly so, and at rest, it has refractive power sufficient to bring parallel rays to a focus on

a retina. These rays being divergent as they enter the eye must, if continued, meet behind the retina, where the image would be formed of the illuminated source if the retina had not interfered. But the observer's retina prevents this and cuts the cone of light on this side of its apex; thus a circular illuminated spot is formed on its surface. The size of this illuminated circle varies, of course, with the distance of the lamp from the mirror and the kind of mirror used, and its distance from the eye to be observed. Experience has shown that a concave mirror is better for illuminating purposes than a plane one; when we substitute a concave mirror of six inches focal length for the plane mirror the same conditions are shown. If the lamp was at such a distance that the rays coming from it were parallel, they would, after reflection, meet at six inches in front of the mirror; but as they come from a distance of only twelve inches, the focus will no longer be at six but twelve inches from the mirror ($\frac{1}{6} - \frac{1}{12} = \frac{1}{12}$). The rays leave this mirror as a converging cone of light, and, if unintercepted, would meet at a distance of twelve inches in front of the mirror. The observed eye, however, intercepts this converging cone and renders it still more converging, and as it is adapted for parallel rays, these converging rays must come to a focus in front of its retina, and crossing here will form the illuminated circle by the time they arrive at the retina.

In regard to the rays which leave the eye, and by means of which the various objects therein become visible, as soon as the rays reach the retina of the eye, they are received by the various membranes and reflected in two ways: first, by regular reflection, as there are some polished surfaces; secondly, by irregular reflection. It is by the irregular reflection that we see the objects at the back part of the eye; by the regular reflection we could see only the details of the source of illumination. The light thrown into the eye by the ophthalmoscope, is received and thrown out by the different membranes just as if they had produced them, and were themselves self-luminous bodies. The mirror, the position of the source of illumination, and the direction of the rays as they enter the eye only affect the extent and brilliancy of the illumination. They exert no influence on the direction of the rays which leave the eye.

If we repeat these conditions, and suppose that the entering rays have crossed each other in the vitreous, and that there is a circle of illumination on the retina, rays will be reflected from every point in the circle. Some will strike the sides of the eye and be again partially reflected and partially absorbed. Such as do find their way out of the pupil must leave the eye parallel to each other, for the surfaces

from which they started are in the principal focus of the lenticular system of the eye, this being normal. Some of these rays will pass through the hole in the mirror, and the eye of an observer adapted for parallel rays and placed against this hole would then be in the track of the rays coming from the illuminated point, and would thus see this point, just as it would any other object.

Loring's instrument was the first practical ophthalmoscope for examining the refraction. Some of the modifications in later instruments had been rejected by him in his experiments.[1] At first he had three discs to contain all the necessary convex and concave glasses, but he soon adopted one disc. Fig. 55 represents the instrument which Loring finally recommended, as the best one for all purposes. This, I have found an entirely satisfactory instrument when well made. It consists of a single disc and a segment of a disc, as the figure shows. Here it is a quadrant of a circle. The single disc contains sixteen glasses, arranged on the metric system. The plus are numbered in *white* and the minus in *red*. The first row of numbers shows the actual strength of the glass. The second shows the result of the combinations, when the quadrant is in position. The quadrant rotates immediately over the disc and contains four glasses, — .50 D, — 16 D, and + .50, + 16. When the combination glasses are not in use, the quadrant is under its cover. The instrument is then a simple refraction ophthalmoscope with sixteen openings, the signs running with an interval of one diopter and extending from 1 to 7 plus and from 1 to 8 minus. To use this instrument we revolve from *left* to *right* and use a single glass up to 7 diopters, then by "bringing up" in the quadrant a + 16 D, and still continuing to rotate the disc from left to right, we obtain + 8 D, + 9 D, + 10 D, etc., up to + 23 D, the highest + number that can be measured with the instrument. If now we turn back the quadrant and rotate the disc to 0, at the aperture, the minus glasses (red) can be brought into use by turning the disc from *right* to *left*, up to — 8 D. By "bringing up" in the quadrant

[1] Those who have an interest in the subject of modifications of the ophthalmoscope for the purpose of examining the refraction, will find an interesting correspondence between Dr. Loring and Dr. Knapp in the Medical Record, June 9th, June 16th, June 23d, 1877.

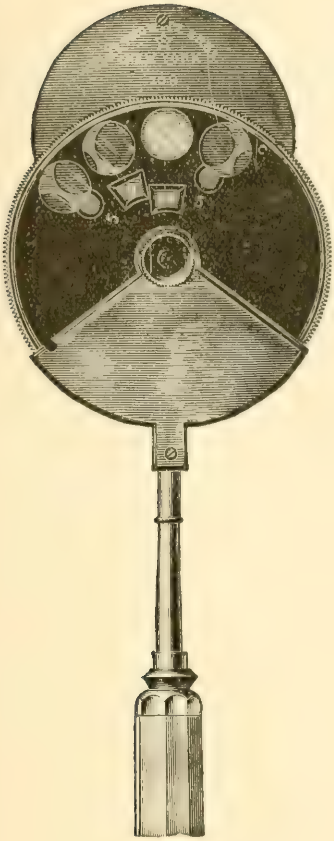

FIG. 55 *A*

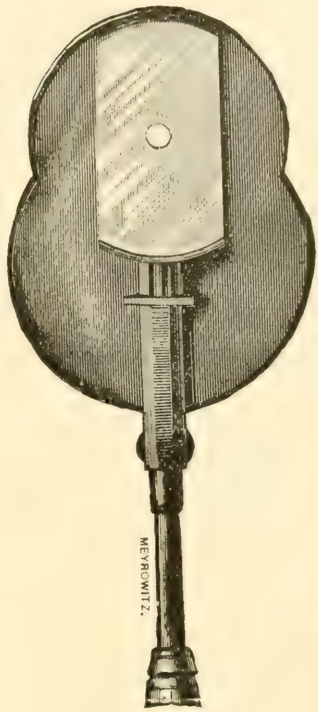

FIG. 55 *B*.

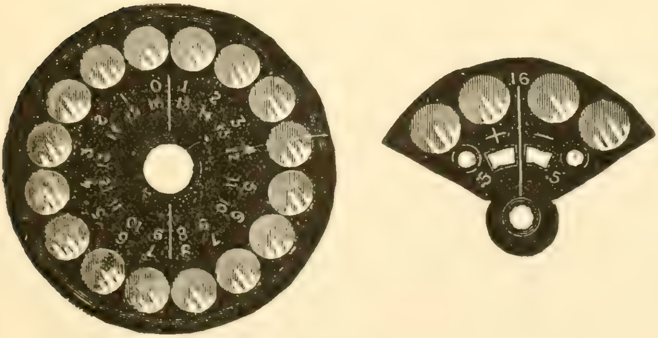

FIG. 55 *C*.

FIG. 55.—THE LORING REFRACTION OPHTHALMOSCOPE.

— 16 D, and continuing to rotate the disc from right to left, — 9 D, — 10 D, etc., up to — 24 D, can be obtained. A total series of eighty glasses may be made by this combination disc.

Many modifications have been made for the purpose, as Loring says, "of determining minute discrepancies of refraction by those who are able, or think they are able, to do it." As will be seen, the author of this work does not consider this a matter of any importance, even if it could be always certainly done. The ophthalmoscope is an instrument whose chief importance, is the determination of the existence of morbid conditions in the fundus oculi and the media. Dr. Wadsworth's ingenious addition to Loring's ophthalmoscope was an additional mirror of circular shape. Loring cut off both sides of this mirror, and swung it on two pins, so that the mirror can be inclined at an angle of 20°. It tilts both ways. It need not be rotated. It is known as a tilting mirror, and has proven a great addition to the ophthalmoscope. I use it for all purposes, as Loring recommends, and not the large mirror.

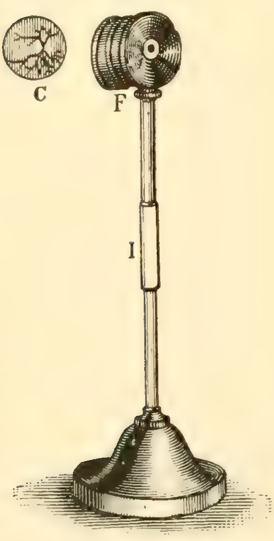

Fig. 56.—Phantom for Practising Ophthalmoscopy.

For the practice of ophthalmoscopy, the student will find one of the artificial eyes adjusted in a frame and having a variety of morbid conditions of the fundus, which may be slid in and out, to serve very well, but as soon as sufficient practice is had, he will confine himself in his examinations to those of the human eye. Among the many varieties of this instrument, some have the back covered (Knapp), some have an arrangement by which the glasses can be readily turned in front of the eye, without removing it (Noyes, Valk). They have been made smaller, and so forth. The practitioner will find in one of Loring's instruments, as made by the original manufacturer, H. W. Hunter, by Meyrowitz, and the other opticians of New York, an instrument that will completely satisfy his wants. Yet if he be extremely critical as to the detail of everything connected with the use of the instrument, he may

prefer one of the numerous modifications, or modify one for himself. It is possible to give too much thought to the instruments to be used, at the expense of the ability to know what is seen with them, or how to operate with them.

Illumination.—Electric light, that from an argand gas burner, or a good lamp, furnish the best source of illumination. Even a candle will do very well in an emergency, either alone or in the lamp figured on page 127. In ordinary cases, with an observer of any considerable experience, it is not necessary to dilate the pupil with a mydriatic. But there will be many instances, for example, when we wish to determine if any minute opacities of the lens have formed, or hemorrhages of the retina have occurred, when the most experienced observer will do well to use a mydriatic, and dilate the pupil, in order to avoid an error in diagnosis. A solution of the hydrochlorate of cocaine, four grains to the ounce, or a gelatin disc of sulphate of atropia, containing $\frac{1}{2,000}$, $\frac{1}{5,000}$, or $\frac{1}{10,000}$ of a grain, are very well adapted for such uses. They dilate the pupil in a few minutes, but the dilatation quickly passes off: if there are no adhesions to the capsule of the lens, the former in ten to fifteen minutes, the latter in a few hours.

When the light enters the eye, part is absorbed and part reflected outward again through the pupil. The reflected rays retrace precisely the course by which they enter. To see the fundus, the observer's eye must be placed in the path of those rays, without intercepting the source of light. Ordinarily this would be impossible. The difficulty is overcome by the ophthalmoscope (ὀφθαλμος, eye; σκοπεω, to look). A person can learn to be a very skilful user of an instrument without understanding the principles upon which it is constructed, just as a navigator may learn to use a sextant without, perhaps, knowing all the principles upon which it was invented. The instrument consists essentially of a small plane or concave mirror, by which light is thrown through the pupil so as to illumine the retina and choroid. The examination should be made in a dark room, with a bright, steady light placed at the side of the patient's head, corresponding with the eye to be observed, on a level with the latter and a little behind it, so that it will be in shadow. The light is received upon the mirror, and reflected thence into the

10

unobserved eye. The mirror thus becomes a source of light, and the observer's eye, placed behind the perforation, can be directly in the path of the rays reflected from the fundus of the eye observed.

THE INDIRECT METHOD.—In observing the inverted image the surgeon holds the mirror close before his eye, and the illuminated eye is observed from a distance of about 12 inches; with the other hand a biconvex object lens of 14 diopters is held vertically before the observed eye, so that the pupil lies about

FIG. 57.—INDIRECT METHOD.

in its focus; the lens may be steadied by resting a finger against the patient's forehead, and another finger may be used to raise the upper lid, if required. An enlarged inverted image of the fundus is thus formed between the lens and the observer. The image may be further magnified by using a weaker object lens, 8 to 10 diopters, or by placing a convex glass from 3 to 4 diopters behind the mirror. The optic disc is best brought into view when the patient directs his eye a little toward the nasal side of the centre; the macula is better seen when he looks straight ahead. The observer should examine the patient's right eye and the patient's left eye with his corresponding

one. In the direct method no object-lens is used, and the observer approaches to within one to two inches, or even with the tilting mirror closer to the eye, using the eye corresponding to the one he examines, and relaxing his accommodation as if he were looking into infinite distance. The image thus seen is erect and apparently behind the patient's eye. It is larger than the inverted image, but the field of vision is smaller. The direct method is preferable for minute and accurate examination of details of the fundus, the indirect for a general survey of the whole background, and for very myopic eyes.

In examining an eye with the ophthalmoscope, after carefully looking at the cornea, the media should be first observed

Fig. 58.—Direct Method.

from a distance of 12 to 18 inches. If the observed eye is moved in all directions, and, especially if the pupil is also dilated, no opacity of the media need escape detection. For detecting very minute opacities, a magnifying glass of ten to fourteen diopters may be used behind the ophthalmoscopic mirror, taking care to have the part examined about at the focus of the glass. With the ophthalmoscope, opacities of the media usually appear black against a red background, while by oblique illumination they have a grayish aspect. If the media are clear, the pupil is filled by a brilliant yellowish-red reflex from the retinal and choroidal vessels, more or less modified by the amount of pigment present. The appearances of the fundus vary greatly within the limits of

health. The optic papilla generally appears as a round or vertically oval disc, about one-seventh of an inch to the inner side of the posterior pole, slightly prominent, of yellowish-white color, most marked on the inner half, often bordered by pigment and by a whitish connective-tissue ring, and marked by white striæ from trabeculæ of the lamina cribrosa. The central vessels radiate from its centre into the retina. The arteries are of a bright color and straight course, with a light-streak along the centre. The veins are larger, darker, and more tortuous, with a less brilliant light-streak. *Venous pulsation* appears on the disc, in many cases, or if not, it is easily pro-

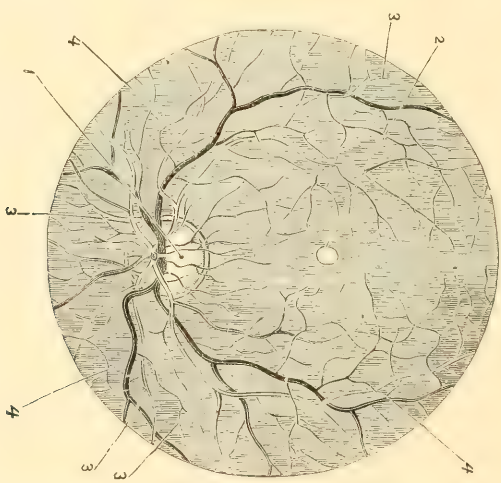

Fig. 59.—Diagrammatic Sketch of Normal Fundus. 1, Optic papilla; 2, macula lutea; 3, artery; 4, veins.

duced by slight pressure on the globe. *Arterial pulsation* is not observable in a normal condition. Near the centre of the disc is a white, glistening, *physiological excavation*, generally small and shallow, with sloping edges over which vessels are seen to dip; sometimes it is large or has sharp edges. The retina is too transparent to be easily seen. It is seen best in dark eyes, especially in those of negroes, where it may appear as a grayish film. The *macula lutea* is the ellipsoidal region at the temporal side of the disc, where, with the ophthalmoscope, no retinal blood-vessels are seen. Near the centre of this space, about two papillary diameters from the disc, and on a line with the lower

part, is a bright spot called the *fovea centralis.* This may be round or semicircular in shape. The pigmented cells may be seen as small dots uniformly studding the fundus, and giving it a granular appearance. In light eyes, the vessels of the choroidal stroma may be seen as bright red bands inclosing intervascular spaces, and even finer vessels and *venæ vorticosæ* may appear. In dark eyes the choroidal vessels may be completely hidden, and the fundus has a mosaic appearance from the abundance of pigment.

In what has been said of the *direct method*, it is assumed that the eyes of the patient and the observer are nearly emmetropic, and with the accommodation relaxed, that is, *adjusted for parallel rays.* Then, rays which emerge from the illuminated fundus of the patient's eye and enter the observer's eye are parallel, and a distinct image is obtained, although the object is but two or three inches away. If the eye observed is not in the condition assumed, the direction of the rays is altered accordingly, and the image is naturally indistinct. In myopia, the emerging rays are convergent; a concave glass must be placed behind the hole in the mirror to render them parallel before entering the observer's eye in order to give him a clear image. In hypermetropia the emergent rays are divergent, and a convex glass is used to make them parallel. The glasses thus required to give a clear image, that is, to render the emerging rays parallel, as in emmetropia or a very low degree of hypermetropia, become also a measure of any existing departure from the standard or emmetropic, or, that is to say, of the refractive defect. If the observer is not nearly emmetropic, he can correct his defect by a proper glass, and then proceed as if he were an emmetrope. If he cannot fully relax his accommodation, he is practically myopic to the degree of accommodation power used, that is, his eye is adjusted for divergent rays. The degree of accommodation used is generally the same, and can be found by experiment. Having found this, the observer should proceed as if he had myopia of that degree. In making calculations, the observer's defect must always be allowed for.

These are the principles on which the direct method becomes so useful for measuring the refraction of the eye. It is a valuable aid to other means, not a substitute for them. This method

is also used for making measurements in the depths of the fundus, as of inflammatory swellings, tumors, and so forth, on the principle that a certain refraction corresponds to a certain length of the antero-posterior axis. The importance of an exact measurement of the axial refraction has been greatly over-estimated by many writers. It is exceedingly difficult, and I think impossible, for the most practised ophthalmoscopists to be correct in every case, as to the degree of hypermetropia, hypermetropic astigmatism, or even myopia. Fortunately, an approximation of the exact condition will do very well, especially since the general introduction of the use of the ophthalmometer, has rendered it much less important to know the exact length of the eyeball than was formerly the case. If there be no loss of vision, and the case appears to be one that may require correcting glasses, or if the ophthalmoscope have determined that the case actually is one without lesion of the retina, choroid, lens or vitreous, the next examination to be made is of the cornea, to determine the presence or absence, and degree and axis, if present, of astigmatism.

RETINOSCOPY—THE SHADOW TEST.

The refraction of an eye may be determined by observing the direction of the movements of a shadow seen by rotating an ophthalmoscopic mirror when illuminating the choroid and retina. If a concave mirror be used, the shadow will be seen to move in a direction opposite to the movement of the mirror in emmetropia, hypermetropia, and also in myopia of such a low degree that the far-point is at a greater distance from the eye than that at which the mirror is held. In higher degrees of myopia the shadow will be seen to move in the same direction as the mirror. A convex lens whose focus is the same as the distance that the mirror is held from the eye being examined, will stop or reverse the movement of the shadow in an emmetropic eye. In hypermetropia this glass must be subtracted from the glass that reverses the shadow. Example: Examination at 30″. If the shadow be reversed by a + 2.50, that is, + 2.50 D subtracted from 1.25 = 1.25 H, hypermetropia. In myopia this glass is *added* to the concave glass which re-

verses the shadow. Example: 1.25 D glass is required to reverse the movement of the shadow, F 1.25 D + 1.25 D = 2.50 D = M. In the examination for astigmatism, the refraction of any one meridian can be ascertained, by noting the movement of the shadow in that meridian.

In England and Germany, where the ophthalmometer is scarcely used, the test by retinoscopy is considered of the greatest importance. At the Royal London Ophthalmic Hospital, Moorfields, it is most carefully taught and most implicitly relied upon, and in some ophthalmic institutions and by many practitioners in this country. It is, however, a method of very little importance when the ophthalmometer is properly employed and relied upon, whatever may be the case. Some authorities even use the ophthalmoscope, the ophthalmometer, and practise retinoscopy, and use test glasses in order to determine the refraction. This I regard as entirely unnecessary and illogical. In low degrees of myopia, when it may be confounded with hyperopia, the shadow test may have a certain corroborative value. The tendency to mistake incipient myopia for hypermetropia exists among those who mistakenly suppose that spasm of the ciliary muscle is a frequent occurrence. To correct this tendency, retinoscopy is useful, for I do not think even the most experienced observers can with certainty, determine by the ophthalmoscope whether in a given case one-half of a diopter of myopia or the same degree of hypermetropia exists.

My associate in private practice, Dr. J. B. Emerson, has practised retinoscopy a great deal. He believes that it is of no positive value except when the eye is under the influence of atropia or some other mydriatic, and that it is of no value, without a mydriatic, in determining whether in a given case a low degree of hypermetropia or myopia exists. The fact that it is of no positive value, except when atropia is used, is an argument for its superfluity as a test, for with atropia, or any good mydriatic, the test by glasses without retinoscopy is sufficient. If we cannot determine the low degrees of myopia by this test, as Dr. Emerson, after great experience, thinks we cannot, then it has hardly a shadow of a claim to rest upon as an auxiliary in diagnosis, for we can positively determine all but this by the ophthalmometer and the refraction ophthalmoscope. The reader

will find this point fully discussed in the chapter on Myopia and Hypermetropia. Dr. Emerson in a verbal communication remarks as follows:

In testing with retinoscopy, the patient is instructed to look at an object over twenty feet distant. In this way it is intended to get a total relaxation of the accommodation. The examination is then made in the region of the macula, but it is really more apt to be near the nerve. In order to get accurate results, the eye should be placed under the influence of a mydriatic, and the patient be directed to look at the mirror. Then we may get the refraction *at* the macula, which, as is well known, often differs from what it is at other parts of the fundus. It is evident that if the patient were not under the influence of a mydriatic, and was instructed to look directly toward the mirror, the act of accommodation and the contraction of the pupil would make the test difficult and unreliable. In acquired myopia from spasm of accommodation, retinoscopy is useless, as the antero-posterior diameter of the eyeball is increased by the action of the ciliary muscle upon the lens, and thus the results with the shadow will be the same as if true myopia existed. The condition can only be positively determined by the use of a mydriatic.

Mr. Bowman[1] (London, 1863) really invented retinoscopy, when he showed that it could be used as a means of detecting differences of refraction in the meridians of the eye by the use of the ophthalmoscopic mirror, as he had previously suggested its use in conical cornea. The mirror was to be held two feet from the eye, and its inclination rapidly varied, so as to throw the light on the eye at small angles to the perpendicular, and from opposite sides, in successive meridians. The pupil then shows a somewhat linear shadow in some meridians rather than others. Mr. Couper,[2] one of Mr. Bowman's pupils, again took up the subject in 1872, and proposed a special mirror of thirty inches focal length, and began his examination some five feet away. Javal, and Giraud Toulon also practised retinoscopy for detecting low degrees of astig-

[1] Donders: "Refraction and Accommodation," London, 1864, page 490.

[2] Transactions Fourth International Ophthalmological Congress, London, 1872, page 109.

matism, without knowing of Couper's work. Since then a vast literature has accumulated upon the subject. The method itself has been variously termed Skiascopy, Keratoscopy, Pupiloscopy, as well as Retinoscopy.

Loring[1] considered it the most difficult and least satisfactory of any of the methods of determining the refraction of an eye, and he thought that it contributed nothing, which could not be more easily and more quickly determined with the upright image. He evidently regarded retinoscopy as only important to the "curious, and those fond of optical problems for their own sake."

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[1] "Text-Book of Ophthalmoscopy," vol. i., page 137.

CHAPTER VIII.

METHODS OF EXAMINATION (*Continued*).

The Ophthalmometer.—Rules for its Use.—Field of Vision.—Perimeters.—The Blind Spot.—The Perception of Colors.—Double Vision.—Paralysis of the Muscles.—Prisms.—The Action of the Muscles.—Tests of their Power Inexact and Unnecessary.—Determination of Binocular Single Vision.—The Simulation of Blindness.—Method of Recording Cases.

To determine the presence or absence of corneal astigmatism we employ an instrument which engaged the attention of Helmholtz, at a very early period in his optical investigations, and which was actually invented by him, but which has only been perfected for practical work in the consulting room in the last few years, chiefly through the labor of Dr. Emile Javal, of Paris, and his pupil H. Schiötz. The instrument now in use is called the Javal and Schiötz ophthalmometer. No practitioner who proposes to do the best work in ophthalmology, can practise without the aid of this instrument.

The ophthalmometer, as invented by Helmholtz, was used by Donders and Knapp, in the first investigations of astigmatism since the days of Dr. Thomas Young. This instrument was suitable only for laboratory work, for it was necessary to make quite formidable mathematical calculations after the observations with the ophthalmometer were finished. For use in the consulting room, it was an impracticable instrument. Javal, after using and modifying the Helmholtz instrument in various ways for a number of years, aided by Schiötz,[1] finally altered and perfected it, so that it can be conveniently used in the consulting room. As now used, the ophthalmometer measures and registers the radius of curvature of the cornea. By it, the difference between the horizontal and vertical meridians can be determined in almost an instant.

The following rules for the use of the ophthalmometer, which

[1] "Mémoires d'Ophthalmométrie," by E. Javal, Paris, 1890.

are drawn from the author's experience, the teachings of Javal and his pupils and the papers of Dr. A. E. Davis,[1] will be sufficient to soon enable the surgeon to secure accurate results. It is aways better, however, for the beginner to get personal instruction in its use, from an expert, if even for a very short period. Many incorrect estimates of the value of the ophthalmometer are made from want of knowledge of the manner of employing it.

1. THE ILLUMINATION.—This may be secured by a large window opening out upon a stretch of fifty feet and upon the sky. A north window is to be preferred. Upon all clear, or moderately clear days, this is sufficient, but if illumination by four electric lamps, each of sixteen-candle power, or by gas can be secured, this is best of all, for it renders the examiner independent of the weather.

2. The telescope or tube of the instrument is correctly adjusted by turning it until the cross-hairs, which are in the tube, are brought in distinct view. This is done by turning the ocular or eye-piece to the right, when the observer is myopic, and to the left, when he is hyperopic. The further to the left the eye-piece can be turned, and the cross-hairs be still maintained in clear view, the better. Dirt in the tube is shown by irregularities in the calibre of the cross-hairs.

3. Place the patient at the instrument with his chin on the chin-rest and his forehead against the forehead-rest, with his eyes wide open and upon a level. To know when the eyes are exactly horizontal, which is all-important, one should sight through the *transverse* slit in the disc just above the tube or telescope of the ophthalmometer. This point cannot be insisted upon too much, for the least rotation of the head will throw the axis off 5° or 10° from what it really is, and then the tests of the axes with the trial case, do not correspond with the finding of the instrument, and the ophthalmometer is blamed, when the examiner is at fault.

4. The eyes being on the same plane, we are now ready to place the little shade in front of one eye, and to focus the other. To focus the eye, sight along the upper side of the tube through the notch (something like a gun-sight) at the centre of the cor-

[1] New York Medical Journal, Sept. 10th, 1892, pp. 291–96; Oct. 8th, 1892, pp. 396–402.

nea. Now sight through the tube, at the same time moving the instrument forward and backward on the table, and up and down by means of the screw, until the image of the disc, doubled by the prism in the telescope and the reflection inverted from the cornea, comes into view. Pay no attention to the two images far out at the sides, but notice the two in the oval space.

5. Get the "primary position." The primary position is that point at which the transverse lines, dividing the mires into halves, become exactly coincident so as to form one continuous straight line. This is simply an indication (when there is any astigmatism) that we have found one of the axes of the astigmatism. The other axis, in the great majority of cases, is 90° from this. It is, therefore, at right angles to it, and is the secondary position. When there is no astigmatism, the transverse lines are always opposite and coincident. When there is irregular astigmatism they are never coincident, and cannot be made so. To obtain the primary position, first turn the long indicator to 0°. If the transverse lines are coincident at this point, go no further; the primary position is obtained. If not coincident at the zero point, turn the tube from right to left, and go on very slowly, until the two lines exactly coincide, if this occurs by the time 135° is reached. If the transverse lines do not become coincident before or when 135° is reached, go no further in that direction, but turn back to 0°, now turning the tube from left to right toward 45°. The lines will necessarily become coincident before 45° is reached. The primary position is *never* further than 45° on either side of 0°. If we turn the tube further than the 135° mark on one side or the 45° mark on the other, the instrument will read astigmatism "with the rule" when it is really "against the rule," and *vice versa*. When the lines become coincident at 135° or 45°—the extreme limits, being just half-way between 0° and 90° on either side—by preference 135° is taken as the primary position. This for the sake of nomenclature. We see, then, that the primary position may be at 0° or any point within 45° of that point, but *never* beyond. Having made the cross-lines of the mires coincident, it is only necessary to approximate the mires to be ready for the next step.

6. Obtain the "secondary position." This is secured by turning the long indicator 90° from the primary position to the left. If

the mires overlap, there is astigmatism with the rule, and the number of steps of overlapping is the degree of astigmatism. If it overlaps two steps, it should be written thus: "Astigmatism with the rule, 2 D. 90° + or 180° –" If the reflectors separate when the second position is reached, it indicates astigmatism against the rule. Before moving the indicator from the second position, approximate the mires again, and then turn back to the primary position, when the mires will overlap—say one-half or one or two

FIG. 60.—METHOD OF USING THE OPHTHALMOMETER.

steps. The result is written thus: Astigmatism against the rule, 180° + or 90° –. Following the rules above, the long index always indicates the axis of the convex glass to be worn, and the short index on the reflectors the axis of the concave glass that is ordered—*in any case.* The tube is always turned from the right to the left, simply that we may conveniently get at the mire which is to be moved. In the cut the examiner is shown moving the mire.

The observer should accustom himself, as in using the microscope and ophthalmoscope, to keep both eyes open during the examination. It is convenient and exact to note the result in writing as soon as one eye is examined. The relaxation of the accommodation, is important in making observations with the ophthalmometer.

Dr. Van Fleet[1] begins at 135°, and thinks there is an advantage in this, as stated below, but I am still strongly of the opinion that most observers will prefer to begin at 90°, as directed in the rules just given and that they form a perfect guide. Everything in them has a meaning.

Dr. Van Fleet's directions are as follows:

"Starting with the bar holding the mires in a horizontal position the long pointer will be at zero. The primary position is obtained within 45° either side. Turning from this point (that is, the point of first position) 90° gives the second position. If the mires overlap in the second position, there is astigmatism with the rule. Any one would know from this description the position in which to put the axis of the cylinder, because *with the rule* implies that the meridian of greatest refraction is nearer the vertical than the horizontal. If, however, the principal meridians are at 45° and 135°, the statement conveys no definite instruction as to the position of the meridian of greatest refraction, except that it is at one of these points, unless we start at a given point for the first position, from which we must turn always in the same direction for the second. This point must be either 45° or 135°. If we start at 135° we must always turn the long pointer to the right, if from 45° to the left. Taking 135° as our point of departure, we move to the right, until the mires line, for the first position. Having obtained this, we continue to move to the right for the second position, and if the mires overlap, we have astigmatism with the rule. The same rule applies if we start at 45°, excepting that we must turn to the left. It will not do, however, to start indifferently from one or the other. One must be invariably chosen as the point of departure, if we would have uniformity of expression and avoid confusion.

"Example 1.—1.00 D. with the rule, axis 90° or 180°. Everybody knows the plus cylinder must be at 90° or the minus cylinder at 180°.

"Example 2.—1.00 D. axis 45° or 135°. Here there is no with the

[1] Paper before the section on Ophthalmology, New York Academy of Medicine, December, 1893.

rule or against the rule. It conveys no idea how the plus or minus cylinders are to be placed.

"Example 3.—Starting from 135°, getting the first position, and continuing to the right, if the mires overlap, calling it astigmatism with the rule, would give an invariable guide for the position of the cylinders no matter where the principal meridians are.

"In place of the method of starting at 0, it would be preferable, and having two points where there is no rule, to abolish the terms with and against the rule altogether.

"No matter where we start, if the lines on the mires coincide and are in apposition, and if they overlap, in turning 90° from this point, the long pointer in the overlapped position indicates the meridian of greatest refraction, and of course the axis of the plus cylinder. We would then say, Astigmatism 45 + 135 —, or 90 + 180 —, etc., etc."

The instrument as finally perfected—so-called model of 1889—consists of:

1. A telescope supported by an upright, mounted upon a tripod.

2. A large graduated steel disc or dial attached to the telescope.

3. A graduated arc.

4. Two mires designated "the steps" and "the parallelogram," which are both attached to the arc.

5. A solid metal brass-finished base, with a support for the head by means of an adjustable chin-rest.

6. Gas or electric light apparatus attached to the head-rest for illumination.

The telescope and disc rest on a tripod, as seen in the picture, which is moved backward and forward on a stand, preferably

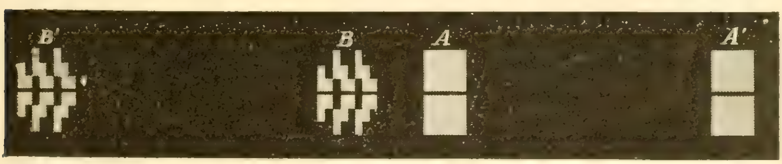


FIG. 61.—THE MIRES.

made of metal. The head-rest is also shown in the picture, and the means of illumination by electric light. The mires are sometimes called targets. They are also represented in the drawing.

It is the overlapping of these mires on the second turning, as described in the directions for using the instrument, which determines the degree of astigmatism with the rule. In the older instrument a complete parallelogram and a parallelogram cut away in the form of steps were used, but the reflected image which is observed on the cornea is, I think, preferably made

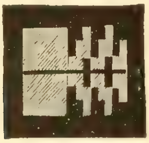


Fig. 62.—Mires Exactly Approximated.

Fig. 63.—Mires Overlapping.

with the mires, than with the steps of the first model. The separation of these mires, on the second turning indicates astigmatism against the rule, and the overlapping on the third turning of 90° would show the degree of astigmatism against the rule. If no astigmatism at all exists, there is no overlapping and no separation on the second turning.

A recent alteration is a thumb-screw, fixed on the graduated arc. By means of this screw, *both* of the mires are made to move at the same time, and to an equal extent, one not remaining fixed on the arc at 20° from its centre, as before, while the other was left to do all the moving. Dr. A. E. Davis has used this improved ratchet in his office for about two months.

Dr. Thos. Reid, of Glasgow, has invented a portable ophthalmometer.[1] I have had no opportunity to use this instrument, and I can say nothing of it except what is said by the inventor, a well-known authority in ophthalmology. The essential parts of his instrument are an aplanatic convex lens of known focus, a rectangular prism neutralized in its centre by a smaller prism, one side of the rectangular prism being adjacent to the lens, and the circular or other disc being opposite the other side in the principal focus of the lens When the instrument is held in front of the convex reflecting surface, with the disc turned toward a luminous body, a virtual image of the disc will be formed at a virtual focus of the convex reflecting surface. This image will only be seen distinctly by the emmetropic eye, through the neutralized portion of the prism when the focus of the lens in front coincides with the virtual focus of the convex sur-

[1] Proceedings of the Royal Society, vol. 53.

face. The instrument is held in the observer's left hand, which rests on the forehead of the patient, the disc being directed to a luminous source to the right of the observer. Dr. Reid states that the instrument resembles that of Javal and Schiötz.

The optical system of the ophthalmometer[1] is composed of two object-glasses, LL′ (Fig. 64), between which is placed a bi-refracting Wollaston prism, W, a positive eye-piece of 56 diopters, and a hair-cross. The whole is carried by a tube of fixed length.

The whole objective system can be drawn back by taking hold of the cone, C, which is in the front of the instrument, and drawing firmly forward without turning, for the system is provided with a pin which assures the position of the plane of division (*dédoublement*) by attachment to the graduated arc. When it is put back in place it must be pushed well back, in order not to get the instrument out of order.

The two object-glasses are alike; their diameter is 40 millimetres and their focal distance 280 millimetres. These two lenses are achromatic and aplanatic, with this peculiarity, that the flints are on the side of the parallel rays, that is to say, that the crowns are turned, one toward the eye which is observed, the other toward the eye-piece. The position of the hair-cross is such that the instrument is in position when the object observed is in the focus of the anterior lens, that is to say, when the luminous rays are parallel between the two object-glasses.

The division given by the bi-refracting Wollaston prism is 2.95 millimetres for the distance where it is placed from the eye observed. The exactness of division, and of jointure of the bi-refracting prism, is secured by a special device, and verified by means of the fine instrument which M. Laurent has constructed for that purpose.

Nothing has been spared in order to attain accuracy in working of this prism and the object-glasses; these three pieces really do credit to the artists who make them, with a regularity which guarantees the satisfactory working of the instrument.

In front of the tube of the glass is seen a cone, the anterior opening of which is 30 millimetres, and which can be unscrewed in order to clean the anterior object-glass, which should be occasionally done.

When the tube which contains the object-glass is withdrawn, the object-glasses can also be unscrewed in order to clean their interior

[1] This description is a translation of an article by O. Sulzer of Winterthur, Switzerland. See Javal, *loc. cit.*, p. 15.

surfaces and the surfaces of the prism; it is very rare that this operation is advantageous.

The eye-piece, O, is easily taken out for cleaning. A division traced the length of the spiral slit, in which a pin works, facilitates putting back the eye-piece invariably at the same point. Each of the divisions corresponds to a displacement of a millimetre of the eye-piece, and each millimetre corresponds approximately to a variation of three diopters of the observer's eye. So that if an emmetrope puts the eye-piece at zero, a myope of six diopters will put it at the second division. The eye-piece moves in a tube T, provided with a pin, and which can be withdrawn by pulling hard. Do not take it out unless the hair-cross needs repair.

The tube of the glass turns wholly in the fixed tube B, which is situated behind the disc D. In order to take the glass apart, hold

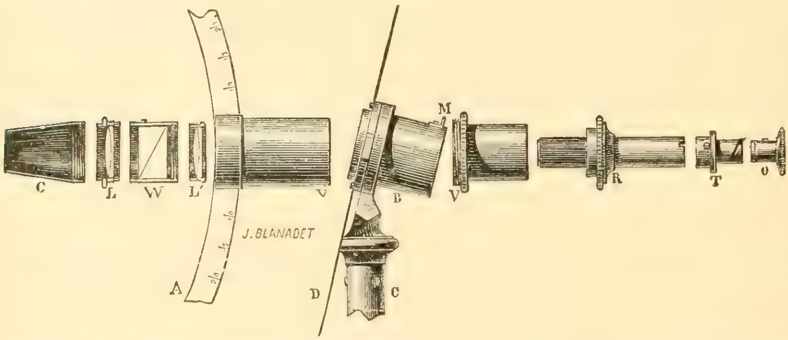


FIG. 64.—THE TELESCOPE OF THE OPHTHALMOMETER WITH THE ARC. L L′, The two objectives; W, Wollaston's bi-refracting prisms; O, positive eye-piece; A, arc; C, column; T, tube in which the eye-piece moves; B, fixed tube in front of the disc.

with one hand the graduated arc with the object-glass, while the other hand unscrews the tube so as to separate V from V′ (Fig. 64).

It is possible then by pulling to take out the tube in front of the disc. This operation should never be performed unless the rotating movement of the instrument about its axis leaves something to be desired. If the movement is too easy, wipe the tube and put it back in place; if it is too hard, put on a little oil, then remount the tube, screwing the pieces into one another. Two notches upon the fixed tube of the glass facilitate putting the instrument in position; they form a finder which helps, by sighting as with a gun, to direct the glass approximately toward the eye under observation.

The tube is supported by a brass column C which is fixed upon a tripod in casting, which slides upon the plane-table. The posterior branch of the foot is supported by a screw designed to regulate the

vertical movements of the telescope. The mean position of this adjusting screw, corresponds to the mean position of the eyes under observation, and its length is such that it is impossible to depart from the limits of the practicable positions of the instrument.

A second slot, situated further forward, is designed for use when it is wished to employ a division (*dédoublement*) one-half less, which makes an extra object-glass necessary.

When the instrument is not in use the adjusting screw should be put in this second slot, to avoid the danger of any awkward person striking the tube of the telescope.

Within the white circle of the large disc (Placido's), are inverted figures which are seen erect in the corneal reflection. These mark the position of the axis of the cylindric glass to be ordered. The markers on the mires, and the long marker placed at right angles to the arc indicate the axis when the instrument is being used. There are also numerous similar circles at increasing distances apart from the centre to the periphery, so arranged that they always are at the same distance from each other in the corneal reflection. They show the size of the corneal image. The large white circle near the centre shows the size of the object on which the calculations of the normal radius of the curvature of the cornea are based, and also the change in the size of the object at each meridian. The numerous radiating lines from the centre, marked in centimetres, are marked in millimetres for measuring the pupil, and at the other side the refractive power is marked in diopters.

Although the student may find much of interest in physiological investigations with the disc, the really important parts with which the practitioner is chiefly, if not entirely, concerned are the markings for the axes and the pointers. He could well dispense with the lines for measuring the pupil and the size of the image.

As is seen in the figure, the head of the patient is supported by the chin-rest and the frame, so that the centre of curvature of the cornea lies approximately at the centre of the curvature of the arc. As has been shown in the description of the method of using the instrument, a more exact adjustment of the distance is secured by moving the telescope until the doubled images of the two mires are reflected on the surface of

the cornea, and very sharply defined. The distance of the image is about four millimetres behind the centre of the cornea.

During the years in which Javal, aided by Schiötz and George J. Bull, was laboring to secure a practical instrument for every-day use in a consulting-room, he made many alterations in the instrument; but that which has been finally settled upon, the model of 1889, has all the qualities that can be reasonably expected of a scientific instrument, although those are not wanting who are still engaged in improving the instrument or the stand. The use of electric lamps, so universal in this country, has, in my opinion, done more than any one thing to popularize the instrument in the United States, since it has made its use independent of the situation of the consulting-room.[1]

The purchaser of an ophthalmometer should be very careful to have the instrument tested by an expert before beginning its use. There have been unjust criticisms upon the truthfulness of the instrument, based upon a worthless prism or other defect in the manufacture, and this in instruments said to have been made in Paris under the eye of Javal himself.

Articles have also been published in this country, which, from a mathematical standpoint, have demonstrated to the satisfaction of the authors, that the Javal and Schiötz instrument is not to be relied upon for the measurement of the degree and axis of corneal astigmatism, and the consequent deductions as to the refraction of the eye. My answer to them is not from a mathematical standpoint, for I cannot even follow these writers in their calculations, but I will say, that both in our practice in the hospital and in my consulting-room, my colleagues and myself find it by far the most exact and complete means of accomplishing just what these writers say it cannot do. I also remember that the man who proved that a vessel could not carry enough coal to take it across the Atlantic by steam, lived to cross in just such a ship.

The important deductions to be made from the findings of the ophthalmometer, and the proper method of ordering glasses from these findings, will be fully discussed in the chapter upon the conditions of the eye requiring the use of glasses.

In 1855, four years after the invention of the ophthalmoscope, an American edition of MacKenzie's "Treatise on the

[1] Ophthalmometers are now manufactured in New York by Georgen & Hahn, and E. B. Meyrowitz, as well as in Paris and Utrecht, and, I think, they are much better here as regards the stand and illumination.

Eye" was edited by one of the surgeons of an ophthalmic institution, and published in Philadelphia. As an introduction to the treatise, a short account of the ophthalmoscope, which had then been invented more than four years, was given. So little was the esteem of even a surgeon of a great hospital of the value of Helmholz's invention, that he made the following remarks in the course of his account of it:

"A great deal more, however, has been expected of and claimed for this instrument, than it is capable of accomplishing, in the present state of its construction. In the first place, the great concentration of light which it produces in the eye, renders its employment highly injurious, even for a few moments of time, in the incipient stages of disease. In cases where it can be endured, its employment for any length of time sufficient to detect all the changes which have taken place, produces an excited and unnatural condition of the structures which are the subject of investigation, and might readily lead the observer astray in his diagnosis. In cases of more confirmed disease, it might not give rise to such annoyances and serious consequences."

In the light of our present knowledge, it is almost inconceivable that such an estimate could be made of the ophthalmoscope. But this experience is not unique. The ophthalmometer is going through the same kind of criticism, and I venture the prophecy that the objections to it, that are now being made, will some day be found to be of no more value than those that were urged against the ophthalmoscope by the American editor of MacKenzie.

TESTING THE EYE WITH GLASSES.

Having learned the visual power and the presence or absence of corneal astigmatism, we turn to the testing of the eyes with glasses. For this purpose, we require what is called a trial case, containing a complete set of convex, concave, and cylindrical glasses.

As will be shown in the chapters upon hypermetropia and hypermetropic astigmatism, it is sometimes unnecessary to go further than this. In many cases of asthenopia from corneal astigmatism, when the vision is $\frac{20}{20}$ or $\frac{20}{20}$ — we may prescribe from the readings of the ophthalmometer alone. Much of the

tedious trial of the days before the ophthalmometer is avoided by the use of this instrument.

TESTING THE POWER OF THE EXTERNAL MUSCLES OF THE EYE.

Many practitioners lay great stress upon an examination of the power of the external muscles of the eye, and there is much ophthalmic literature and practice, based upon such examinations. For reasons which I have fully given in the body of this work, in the discussion of asthenopia, I do not ever use instruments for this purpose, and I give no account of them in this book, although the test by prisms of the degree of deviation in paralysis will be fully given elsewhere.

FIELD OF VISION.

In certain cases of supposed or actual disease of the optic nerve, also in glaucoma, and some other affections of the back part or bottom of the eye, it will be important to determine the size of the visual field. By this term, we mean the space in which the patient can see, when the gaze is steadily fixed upon an object held exactly in the direct line of vision—that is to say, the space in which the patient can see objects, when the *macula* is fixed upon them. This can be rudely done, but with sufficient accuracy in some cases, such, for example, as cataract, when we only desire to know whether the retina and choroid are sound at the periphery, as well as at the centre, by using a candle flame in a darkened room. The procedure is as follows: The eye not to be examined is carefully covered with a napkin, or the like, and the candle flame is held exactly in front of the pupil of the other eye. The examiner now holds his hand between the light and the patient's eye, and causes him to keep the gaze steadily fixed in the centre, while the light alternately shaded and revealed is brought to the lower and upper, outer and inner, side of the patient's face in turn. In this way, it can be readily and exactly determined whether the flame is seen in all parts of the field alike, with equal distinctness, or whether any defect occurs. (See Cataract.)

For cases of disease, or suspected disease, of the bottom of the

eye, however, a more exact examination must be had, and the field carefully mapped out and recorded. For this purpose, a perimeter is to be used. There is a large variety in these instruments. A convenient and portable one is that modified by Dr. J. B. Emerson. This is used by the surgeons of the Manhattan Eye and Ear Hospital, both in private and public practice. It is an excellent instrument, giving accurate results (see Fig. 65).

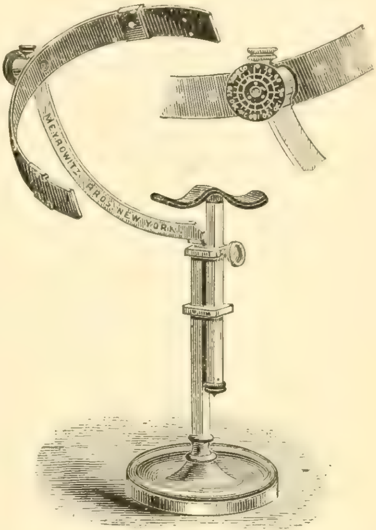


FIG. 65.—EMERSON'S PERIMETER, WITH TWO SLIDING OBJECT-CARRIERS ON SOLID BRASS BASE. The arc is a semicircle of 12.7 cm. (5 inches) radius, revolving on a hollow spindle, and is divided on its convex surface into eighteen equal parts, numbered from the centre to the extremities. On each arm of the arc is a perforated slide, so made that small pieces of paper can represent the objective point; in testing the color-zones, colored paper can be used. The arc is supported by a quadrant, mounted upon an adjustable upright set in a firm brass base. The scale on which the angle of revolution is measured is fixed to the quadrant, and a pointer attached to the revolving arc indicates the meridian tested. The chin-rest is double, the right for the left eye, and *vice versa*. The eye of the person tested should be 12.7 cm. (5 inches) from the aperture, and on a level with it.

The following is a method without a perimeter. Place the patient about twelve inches from a blackboard, and have him direct the eye to be examined (the other one being covered) toward a small dot or cross marked in the centre of the board. Take a piece of chalk fastened to the end of a stick, and advance it slowly from the edge of the board, and mark the spot where it is first seen, not as chalk, but merely as something white coming toward the eye. Repeat this in every direction, and join the marks by a line. This maps out the *quantitative* field. By marking in the same way the points where the patient can first *recognize* the approaching object, as, for instance, to count fingers, the *qualitative* field is obtained. By using bits of colored paper as objects, the different color fields are obtained. In the normal eye blue has the largest field, red the next, green and yellow next. *It is essential in these tests that the patient keep his eye fixed upon the central dot, during the whole examination.* If vision is reduced to perception of light, the patient is made to keep his eye directed

straight forward, and a lighted candle is used in the same way as the chalk to determine the limits of the field.

A convenient and rapid way of testing the field is as follows: Place yourself two feet from the patient, with your eye on a level with his, and directly in front of it. If testing his right eye, for example, have him look steadily with this into your left eye, the other eye of each being closed, then by using the testing object midway between, that is, a foot from each, you can map out the patient's field, and at the same time compare it with

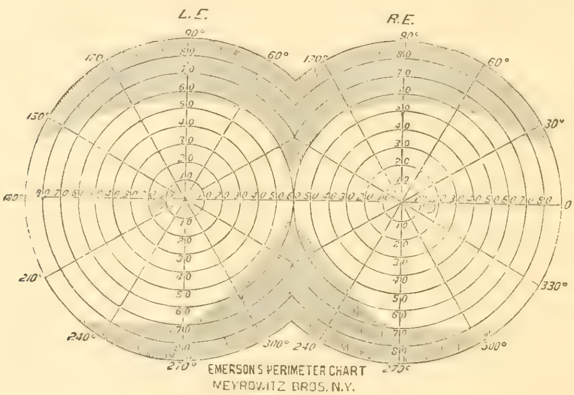


FIG. 66.

your own, which is supposed to be normal. The field may be concentrically, or irregularly, contracted or interrupted by scotomata (Gr. σκότος, darkness) or blind spots. To test for scotomata, carry the objects from various parts of the periphery of the field quite up to its centre, and observe whether there are areas where it is indistinct, or where it disappears from view altogether. Sometimes the right or left half of each field is wanting—*homonymous* or *equilateral hemiopia* (ἡμι, half, and ὄψις, vision). Sometimes the outer half of each field is lacking, *temporal hemiopia;* sometimes the inner half, *nasal hemiopia.* In the normal field, there is always a blind spot, corresponding to the optic disc, whose fibres are insensible to light. This is called the "blind spot of Mariotte," after the man who first described it (Mariotte, France, seventeenth century). Under ordinary circumstances it is not noticed, and occasions no inconvenience. Each point of the field corresponds to an opposite

part of the retina, for example, the temporal fields correspond to the nasal half of the retina, and the nasal to the temporal. Charts for recording the results of the examination go with the instruments.

COLOR BLINDNESS.

It becomes necessary for the ophthalmic surgeon to make tests for that important condition known as color-blindness. The physiology and pathology underlying this condition are fully discussed in the chapters upon Disease of the Retina and Optic Nerve, but the method of determining the condition may perhaps be as well described in this chapter.

The perception of colors may be defective congenitally, or from disease. It is best tested by worsteds, representing the ordinary primary colors and their different shades. A skein of worsted representing one of the primary colors, for instance green, is laid out, and the patient is directed to put beside it all the samples which seem to him to be of the same color. The other primary colors are used in the same way. Tests which simply require the patient to *name* the colors are not considered reliable, for the reason that the color-blind learn to name colors correctly from the intensity of their illumination, and so forth. The worsted test is known as Holmgren's (Prof. Holmgren, Sweden, nineteenth century).

Holmgren begins with light green, and when mistakes are made with this, he takes up some shade of rose, a color between red and blue. He divides all cases of color-blindness into total and partial color-blindness. In the former colors are not distinguished from each other as such, but according to their relative brightness. Partial color-blindness Holmgren divides into red-green, and violet blindness. In the toxic amblyopias, the color-sense is impaired in certain parts of the field. This is tested by red and green cards held on the pointer of the perimeter.

DOUBLE VISION.

(*Διπλοος*, double, *οψις*, vision.)

The determination of the seat of double vision is an important matter. There is no symptom of the eye, unaccom-

panied by pain, that is more disturbing to the patient. It is fundamentally important to determine which muscles are at fault, where double vision occurs. This may be done in the following manner: a lighted candle, or some similar source of illumination, is placed on a stand twenty feet away, and one of the patient's eyes is covered by a red or other colored glass, red preferably. These colored glass discs are found in the trial

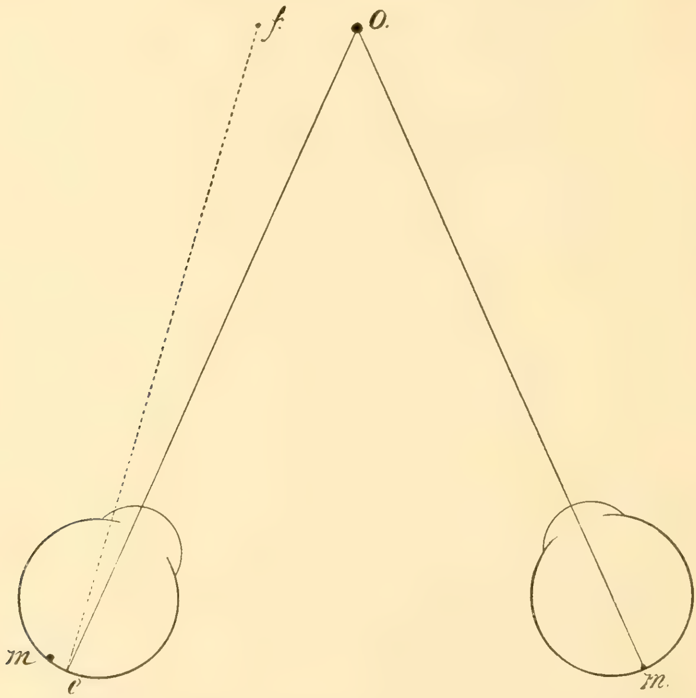


FIG. 67.—Represents the diplopia resulting from convergence of one eye. The right eye is directed toward the object *O*, the image of which falls on the fovea centralis of the macula at *m*, and is projected correctly to *O*. The left eye is convergent, the macula being turned outward. In this eye the image of *O*, instead of falling on the fovea centralis, falls on the retina at a point *c*, at the inner side of *m*, and is projected to a point *f*, at the left of the true image, and a false image is produced. This is homonymous diplopia.

cases. If the patient has double vision at that distance, he will see two lights, one a red, the other of the normal color. It is by the position of these two lights, relatively to each other, that we determine which muscle is at fault, in the absence of muscular equilibrium. If the red glass be in front of the right eye, and the patient sees the red light on that side, there is so-called

homonymous diplopia, and we have a paresis of the external rectus muscle, convergent strabismus, which is supplied by the sixth nerve, and if the paresis be of any considerable degree, convergent strabismus will be observed. This muscle has become so weakened that its antagonist, the internal rectus, overbalances it. The eyeball being displaced inward, the macula lutea is displaced outward, and homonymous diplopia results.

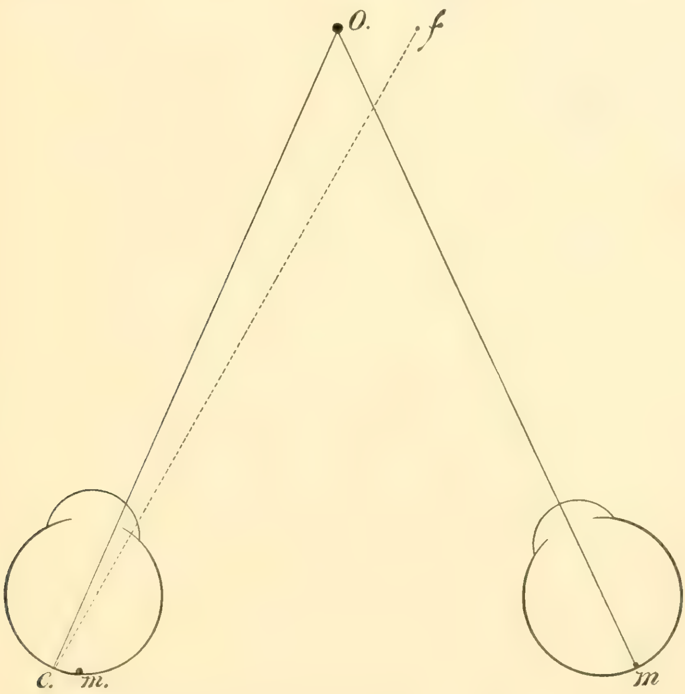


FIG. 68.—Represents the reverse, or crossed diplopia. In this, the left eye is divergent, the macula being turned inward, and the image of *O* falls on the retina at a point *e*, at the outer side of *m*, and is projected to *f*, at the right of *O*. The greater the deviation of the visual lines, the wider apart will the two images seem, and the less distinct will the false image, *f*, appear.

If crossed diplopia is found, it is the internal rectus that is at fault; the eyeball is displaced outward, and the macula inward, with a consequent crossed double image—that is to say, the patient sees the red image on the opposite side. If no actual double vision occurs by this test, a halo may be thrown on the light, or it may be said to blur. The deviation in that case is so slight that a distinct image cannot be formed.

LATENT INSUFFICIENCIES.

A great deal of stress is laid by some writers upon latent insufficiencies, which are brought out by the use of prisms. This subject will be fully discussed later, but it may be well to say here that in all cases of actual paralysis of the ocular muscles, the candle flame and colored glasses will detect it. It may sometimes be necessary to reduce the distance at which the candle flame is placed, or to hold it in a certain direction, in order to demonstrate the double vision, and to show which muscle, or muscles, are at fault.

Vertical diplopia will be discussed under Paresis of the Ocular Muscles.

PRISMS.

A prism bends the rays of light in the direction of its base, according to the size of its angle. If, while regarding an object, a prism is placed before one eye, with its base inward, the rays from the object will be deviated inward, and the image will be formed on the retina inside of the macula. There will be homonymous diplopia. The eye will instinctively try to overcome this by rolling outward, so as to bring the image again upon the macula. If this effort be successful, single vision will thus be restored, provided the prism is not too strong. Prisms are much used for testing strength of the muscles, the strongest one which can be overcome by them being taken as measure of their power. For example, if, while looking at an object twelve feet distant, a prism of 15° with the base inward can be placed in front of one eye (or a prism of 7½° in front of each eye) before the ability to fuse the double vision is lost, we may consider that the prism is a measure of the power of the external recti at the distance named. Thus also, where there is diplopia, the strength of the prism required to fuse the images becomes a measure of the deviation of visual lines. For example, if there is crossed diplopia, and the images are united by a prism of 15°, placed before one eye with the base inward, we say that there is weakness of the internal recti, of 15°. The eyes are able to unite double images widely separated laterally, but cannot unite those showing more than a very slight differ-

ence in height. If a prism of 10°, base upward or downward, is placed before one eye, a diplopia is thus produced which cannot be overcome. The impulse for single vision is annulled, and the eyes yield passively to the muscles which happen to be the strongest. This fact is made use of in the prism test as to the power of the internal recti.

To examine *the action of the muscles*, the patient may be directed to look at a pencil and to follow it with both eyes, without moving his head, while it is carried slowly in various directions through his circle of vision. If a muscle is insufficient, or paretic, the eye may often be seen to waver and lag behind its fellow, when turned in the direction of such muscle's action. For example, if the right *externus* is weak, when the pencil is moved to the patient's right side the left eye will follow it, but the right will not, or will do so in an uncertain, faltering manner. The *internal recti* may be tested as to their converging power in the following manner:

1. The patient may look at a pencil with both eyes, while it is gradually advanced to within four or five inches, the surgeon observing whether they remain fixed upon it, or deviate outward.

2. While both eyes are fixed upon the pencil, one may be covered by the hand, so as to exclude it from vision, but still allow of its being watched. If its *internus* is weak, it may be seen to roll outward, as soon as its visual sensation is thus cut off.

3. Draw a fine vertical line upon a piece of white paper, and in the middle of the line make a round, black dot one-third inch in diameter. Let the patient hold this at his ordinary reading distance and look at it, while a prism of 12°, base upward or downward, is held before one eye. Two dots, one above the other, will then be seen. If the muscles are normal, the dots will be on same vertical line; if the *interni* are weak, they will be separated laterally and *crossed*, that of right eye being on left side and *vice versa*. In the latter case, by placing other prisms, base inward, before the eye, the dots may be brought into the same vertical line, and the strength of the prism required for this measures the deviation, or weakness of the interni, which is present. If images are separated laterally and are homony-

mous, it shows deficient action of the *externi*. Prisms placed base outward before the eye will bring them into the same vertical line. The prism required will measure the muscular weakness. A candle may be used instead of a dot.

The most common defect in muscular equilibrium is ordinary *squint*, which is generally discovered at a glance (see Strabismus). Other defects are often so slight as to be very difficult of detection. Great caution should be exercised in making deductions from the use of prisms in estimating the power of the ocular muscles. Different results are often obtained from the same patients at different examinations, and by practice patients learn to overcome prisms, and see single with them, which on the first trials produced double vision. A careful study of the refraction, renders tests for muscular equilibrium entirely unnecessary, as I have shown [1] the muscular power of eyes of persons without asthenopia does not come up to the so-called normal standard, in a large proportion of cases. There is probably no standard of muscular equilibrium in the eye. The power of the muscles varies very much in different persons, with, apparently, equal freedom from ocular fatigue, and in the same persons from day to day, just as does that of other muscles of the body, the grip of the hand, for example. I no longer use these or any other tests for the power of the external muscles, except in paralysis and strabismus, and I do not recommend them to my pupils in my lectures.

TESTS FOR BINOCULAR SINGLE VISION.

It is often important to determine whether binocular single vision exists. A simple test is to hold a pencil midway between the eye and a page of print, while reading. If there is binocular vision, the pencil will not interfere with a view of any part of the page. If only one eye is used, the pencil will obscure the view just in proportion to its size. The prism test consists in holding a prism with the base upward or downward in front of the eye. If double vision appears, it proves the existence of binocular vision. Quite a contingent of eyes become so different

[1] Medical Record, April 19th, 1890.

in visual power from disease, or are congenitally of such different refractive power, as to be independent of each other.

THE SIMULATION OF BLINDNESS.

Conscripts desiring to avoid army or navy service, those desiring discharge or pension, neurasthenic and hysterical persons, young lads or misses wishing to avoid school and study, malingerers of whatever variety, sometimes feign blindness of one eye. If such persons have undergone many examinations, it is some-

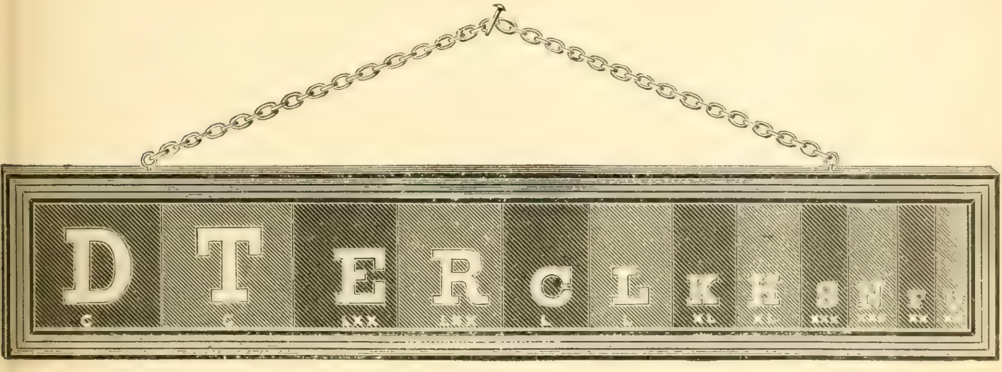


FIG. 69.—SNELLEN'S TEST FOR SIMULATING BLINDNESS. This test consists of a series of alternately red and green transparent letters on glass, corresponding in dimensions to the Snellen test for distance. They are accompanied by a pair of spectacles containing in one eye a red and in the other a green glass. As these colors neutralize all letters not of the same color of the glass held before, that is, only red letters can be seen through the red glass, and only green through green glass, a person with normal vision sees only one of any two letters selected according to the distance. From the statements of a patient claiming to be blind of one eye, we may very readily make correct conclusions as to their truthfulness. As a color test it may be also of some value.

times difficult to detect the fraud they are practising, but with beginners in this kind of deception it is not difficult. The use of a prism will be sufficient. If it be held before the eye of which no complaint is made, and double images are seen, the fraud is at once detected. But, as has been intimated, this will only be sufficient with beginners in malingering. Malingerers soon become familiar with the action of prisms, and deny that it produces double images. We may then have recourse to the stereoscope.

The stereoscope is a very efficient means of detecting malingerers, who claim that one eye is blind. Unless such persons are

very well informed in optics, or the principle of the stereoscope, they will be detected. For example, a card may be arranged and put in the instrument with the words "You lie," reversed, placed in the instrument as Lie—You. They will, of course, see but one word, if blindness actually exist, while if it does not they will read the opposite word. Dr. John Green has arranged a large series of these cards for use in the stereoscope to test the existence of binocular single vision. They are of great service.

It is hardly necessary to say, that there are very few cases in which any such complete examination as has been here outlined, will be required. But there are a few, where every resource in examination will be necessary, and many in which much time will be required to determine if a disease of the eye exists, and if so, upon what it depends. A narrow specialism will be of avail in but few of the important cases that come to the oculist. He who would be a competent specialist, must first be an experienced general practitioner. Any one may learn in a few days to remove a foreign body from the cornea, or to perform more important operations upon the eye, or to adjust a glass for a myopic patient, but whoever undertakes to understand the philosophy and significance, and apply the proper treatment and outline the prognosis in ophthalmic deviations from the normal should be first a well-educated and experienced practitioner from service in a large hospital, or in general practice.

HISTORY OF CASES.

The surgeon who desires to give to the profession the benefit of his experience, should keep a history of his cases. Each practitioner, having a large number of cases, will gradually fall into his own plan for this. It is a mistake to note down so much as to impair the memory of cases, and the capacity to think them over and out, but, in refraction cases especially, and even in others, unless at least an outline is kept, an exact description of them will be impossible. The formula given below is one which has been evolved in my practice, and one which I can commend to the young practitioner, as one that will serve his purpose until his needs and experience have made a better one.

A blank book is prepared and the cases noted in it. Some ophthalmologists prefer to make their histories on cards. The danger of losing or mislaying these, as compared with the security of having bound volumes, placed like other books on the library shelves, seem to me to outweigh the advantages of the card method.

Vol.

Operation performed,

Prominent feature in the case.

Sent by

Diagnosis,

No.

Date,

Occupation,

Name,

Age,

Address,

History and present condition,

R. E.

L. E.

Vision,

Refraction,

Ophthalmometer,

Ophthalmoscope,

Advice and Treatment,

CHAPTER IX.

THE PRINCIPLES OF TREATMENT AND THE REMEDIES APPLICABLE.

Treatment of the Eye not merely a Local Matter.—Constitutional Conditions Important.—Bright's Disease.—Nervous Exhaustion.—Hot and Cold Applications of Water.—Caustics and Astringents.—Alum.—Sulphate of Copper.—Tannic Acid.—Boracic Acid.—Mydriatics.—Cocaine.—Irritants.—Ointments.—Jequirity.—Exclusion of Light.—Aseptic and Antiseptic Precautions.—Bandages.—Absorbent Cotton.—Eye-Shades.—Protective Spectacles.

GENERAL REMARKS.

It is sometimes assumed that the treatment of the eye is a local matter, not involving general therapeutics to any considerable extent. This is hardly true of any single disease of the eye. In each of its diseases, after all the varied injuries that it may suffer, before and after the performance of surgical operations upon it, a large knowledge from actual experience of the principles and practice of medicine and surgery may be, and generally is, required. Besides this, there are various constitutional conditions and diseases, which bring in their train affections of the eye. In some of these, the eye may be among the first organs to give positive evidence of general disease, this being notably true of Bright's disease, locomotor ataxia, diabetes, and neurasthenia, or nervous exhaustion. Many a diagnosis of the former disease has been first made by the ophthalmoscope. In nervous exhaustion, asthenopia is very likely to become a prominent symptom. This is also true of diabetes, while in incipient locomotor ataxia, inability to fix the eyes steadily for an ordinary period of time and other indications of asthenopia, are among the symptoms to be looked out for. It does not enter into the scope or province of this volume, to present detailed accounts of the general diseases which may affect the eye. However much special knowledge the practitioner may have of the anatomy and physiology of the eye, and of its local symptoms when diseased, he

must have a good knowledge of and experience with the symptoms of constitutional or general disease, or he will fail in attempting to become a competent specialist.

But in this chapter it is only intended to speak fully of the local means of treatment in the affections of the eye.

COLD AND HOT APPLICATIONS OF WATER.

In acute stages of purely conjunctival disease, cold water is usually a grateful and efficient application. After injuries of the lid from accident or surgical interference, this is also usually true, as well as after operations upon the muscles of the eye. An efficient way of making these applications, is to apply a bit of linen, sufficiently large to cover the eyelids, to a block of ice, and then, when it has become cold, to the closed lids. A nurse should sit by the patient and renew the application every moment, so that it may never be a warm one. In the case of very young children, care should be taken that the integument be not frozen or unduly chilled, by the application. When the acute symptoms have begun to abate, the patient will no longer find these cold applications pleasant. Neuralgic pains will arise and they should be discontinued. Indeed, the patient's own feelings will generally be a good guide as to the propriety of cold or hot applications. The ice coil is sometimes recommended for making cold applications to the eyelids, but its weight, as well as that of ice-bags, renders it inapplicable.

HOT APPLICATIONS.

These are especially appropriate in inflammations of the cornea and iris, in phlyctenular inflammation of the conjunctiva and cornea, in ulcerative keratitis, in the declining stages of conjunctival catarrh, and sometimes in purulent conjunctivitis. They are best made from a bowl of boiling water, or nearly boiling at the patient's side, from which with little wads of absorbent cotton, or soft linen, the eyes are sopped by an attendant, or in many instances by the patient himself. It is convenient to keep the water constantly heated by means of a spirit-lamp, under a tin vessel containing the water. The vessel may rest on two bricks, or the like, and the lamp placed between them.

CAUSTICS AND ASTRINGENTS.

It was formerly much the practice to use nitrate of silver, even in a solid state, and later in what is called the mitigated stick,—nitrate of silver and nitrate of potash—in purulent conjunctivitis. But this application should only be mentioned to be condemned. Experience has shown that the reaction after the use of nitrate of silver in this form, is too severe, and its use in this way has been generally abandoned.

Nitrate of silver, in solution, however, remains a valuable remedy, but it should always be used with great caution in ophthalmic therapeutics, and only by experienced hands. I never employ a solution to the conjunctiva of greater strength than ten grains to the ounce. It should be neutralized by a solution of common salt and water, or by vaseline well smeared over the conjunctiva. This I do not give into the hands of a patient, but I apply it myself. Very weak solutions of nitrate of silver, one or two grains to the ounce, are often very efficient in chronic conjunctival catarrh, and may be used by the patient himself. In purulent conjunctivitis some practitioners use, and with good results, a solution of one-eighth grain in a spray. It acts at once upon the epithelium of the cornea, and as soon as the loss of lustre caused by it appears, the application is discontinued.

Small pipettes are now universally used in making applications of solutions to the eye. Fig. 71, page 183, shows the usual varieties, and how they may be made as stoppers to vials containing the solutions.

Alum, in crystal form, is one of the safest and best astringents, either in the hands of the surgeon or the patient, and when indicated a very efficient one. In both instances, it is a safe application. It has not yet been displaced, old as its use is, by any modern remedies. In solution it is also an excellent astringent, in the strength of from one to two grains to the ounce.

Sulphate of copper, in crystal, after a century of use, still holds a first place as an astringent caustic in trachoma. It is not as much used in solution. It is worthy of remark, that the reaction from the application of sulphate of copper, may be

modified according to the force used in making an application with it. A gentle passage of the crayon across or over the conjunctiva, will produce, in many cases, just sufficient reaction, when an application made with considerable pressure may be too severe. The surgeon may, therefore, in some degree govern the strength of his application by the pressure he exerts in making it.

Sulphate of zinc and sulpho-carbolate of zinc, are hardly inferior to alum as mild astringents, in two-grain solutions to the ounce. *Tannic acid* in combination with glycerin is a valuable remedy also, especially in chronic conjunctivitis, applying a drop in the corner of the eye, two or three times a day. In trachoma especially, a very strong solution may be used, from ʒi. to ʒij. to the ℥i., a saturated solution.

Boracic Acid and Common Salt (*Chloride of Sodium*).—Solutions of these agents are chiefly valuable as very mild eyewashes in chronic conjunctival disease, or after operations upon an eye that in healing have left some conjunctival hyperæmia. A saturated solution or boric acid and water is proper. Were it not so common and simple a remedy, a solution of common salt and water would be much more used. In the strength of about one drachm of finely pulverized salt to a pint of water, it is an excellent application for cases of chronic conjunctivitis or hyperæmia of the conjunctiva. These are generally less irritating applications than simple water. A solution of boric acid is also, as will be hereafter shown, a very bland fluid for cleansing the eye before an operation.

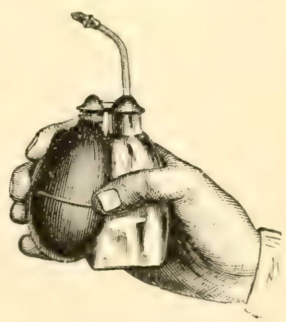


FIG. 70.—NEBULIZER FOR SPRAYING THE CONJUNCTIVA.

Biborate of soda and camphor, ʒi. to ʒiij., is a deservedly popular application among oculists for chronic conjunctival irritations or inflammations. Almost any patient who takes the treatment of his eyes into his own hands, begins with a proprietary medicine known as Pond's Extract. This is a preparation of witch hazel. It seems to have no advantage over boric acid, or common salt and water, or plain water. A convenient and efficient means of making applications

of mild astringents and cleansing fluids to the conjunctival sac is by means of a hand-atomizer, which was introduced into the practice of the Manhattan Eye and Ear Hospital by Dr. Agnew, where it is still in daily use.

The cold douche is chiefly used with benefit in some cases of obstinate phlyctenular disease of the conjunctiva and cornea, attended by very severe photophobia. The cold douche is chiefly used in children who present great spasm of the orbicularis muscle and photophobia. The child's body and arms are firmly held while its face is forcibly dipped into a basin of cold water, just enough to submerge the eyes, and is held there for a few seconds. The dipping may be repeated several times in quick succession.

MYDRIATICS.—These are among the most important of agents in the treatment of ophthalmic disease. The chief ones are: 1. Atropia. 2. Cocaine. 3. Homatropia. 4. Duboisia. 5. Scopolamia.

Of all these, atropia, used generally as a sulphate, easily holds the first place. Prepared with castor oil, it is sometimes a very efficient mydriatic when the watery solutions fail. This is probably because they are sometimes rapidly diluted with the tears before having an effect. For general use the aqueous solutions are preferable.

In the use of castor oil solutions of atropia, it is well to use the alkaloid, as recommended by Green, of St. Louis, and not the salt, and also to see that the apothecary renders the castor oil aseptic before dissolving the alkaloid in it.

Atropine (active principle of belladonna) contracts the blood-vessels, and paralyzes the sphincter of the pupil and ciliary muscle, and puts the eye in a state of complete physiological rest. It is applied directly by being dropped from a dropper into the lower conjunctival sac, or it is pencilled upon the inner surface of the lower lid with a camel's-hair brush. It is absorbed through the cornea and conjunctiva, and the effects appear in a few minutes and last several days. It acts on the peripheral ends of the nerves, paralyzing the filaments of the oculo-motor nerve, and stimulating those of the sympathetic (?). The pupil first dilates and then the accommodation gradually becomes paralyzed. It is used in a solution of 1 to 4 grains to an ounce of sterilized water, and this is sufficient for all

ordinary purposes. A very weak solution ($\frac{1}{8}$ gr. to 1 oz.) dilates the pupil without much effect on the accommodation, and is thus useful for making ophthalmoscopic examination, although of late its place is largely taken by cocaine. Atropinized gelatin

FIG. 71.—DROPPERS FOR THE EYE.

and paper discs are sold, and are very convenient. Ointments containing atropine may also be used. The patient should always be told beforehand of the effects of the drug, else he will sometimes be frightened, and accuse the surgeon of "taking away his sight." This is no fancy picture. It is quite a common experience in hospital and private practice, to find patients coming with dilated pupils, with bitter complaints of the physician, to whom they have not returned, because they believe he has damaged their sight. In some cases, atropine has a poisonous effect, shown by increase of inflammation, pain, irritation of the lids and conjunctiva, eczematous eruption, and so forth, and has to be discontinued. One-half grain sulphate zinc added to each ounce of solution will sometimes prevent this. Its local use often causes unpleasant feelings of dryness and constriction about the throat. It is a wise precaution to advise that the drops be put in after eating. Very rarely it causes alarming symptoms of belladonna poisoning. Morphine is the proper antidote. Atropia, as first clearly pointed out by H. Derby,[1] may precipitate an attack of glaucoma, in persons predisposed to this disease. This is said to be true also of homatropine and cocaine.[2] While I have observed the breaking out of glaucoma from the use of atropia, I have never observed it from the use of any other mydriatic.

[1] Transactions American Ophthalmological Society, 1868.

[2] Fuchs: "Lehrbuch," p. 370.

Duboisine (the active principle of Duboisia myoporoides) produces the same effects as atropine, but acts more powerfully. It is used in solutions of the same strength as atropine.

Homatropine is also used as a mydriatic, but chiefly to paralyze the accommodation, in a solution of four grains to the ounce. It is decidedly inferior to atropia for this latter purpose, but its effects are much less lasting.

Scopolamine, an alkaloid from the roots of the Scopolia atropoides, has lately been introduced as a mydriatic by Raehlmann and Hasket Derby. I have used it for some months, and I find it a very efficient mydriatic. Whether it has any advantages over atropia remains to be seen, but in iritis it is prompt and efficient. It is used in the strength of from one to two grains to the ounce.

Hydrochlorate of Cocaine.—This drug, which is chiefly used as a local anœsthetic in operations upon the eye (Carl Koller, 1885) is also valuable as a mydriatic, especially when very temporary effects are desired, as in ophthalmoscopy. A solution of from eight to sixteen grains to the ounce may be used, or, if preferred, it may be employed in gelatin discs. It may be used more freely than atropine, but, since it removes or dulls the epithelium of the cornea very rapidly, a little caution is necessary, to keep the cornea moist by rubbing the lids over the eye, and by dropping water in the eye.

MYOTICS.

Myotics, or agents which contract the pupil, are of much more limited application. Calabar bean is a type of myotics. It contracts the pupil and causes a spasm of the muscle of accommodation. It will overcome weak solutions of atropine, but not strong ones, and its effects are brief. *Sulphate of physostigmine and sulphate of eserine*—both alkaloids of calabar bean—are the myotics most commonly employed. Eserine is useful in much the same cases of inflammation as atropine, excepting iritis. It is said to contract the vessels, to lower the intra-ocular pressure, and to lessen diapedesis or exhalation of the blood. It sometimes causes irritation of the eye. Both eserine and physostigmine, have been highly recommended for suppurative dis-

eases of the cornea. The sulphate of eserine has a well-deserved reputation in the relief and even cure of glaucoma.

Pilocarpine (the active principle of jaborandi) is similar to eserine in its effects on the eye, but is not so useful. Used hypodermically (hydrochlorate of pilocarpine, dose $\frac{1}{8}$ to $\frac{1}{3}$ grain) as an alterative and absorbent, it acts very favorably in episcleritis, choroiditis, and for clearing up vitreous opacities. Used in this way, it occasionally produces alarming prostration, accompanied by vertigo, nausea, and vomiting. It also causes sweating, salivation, and lachrymation. Its great value in choroiditis is due probably to the excitation of the action of the absorbents. Eserine, physostigmine, and pilocarpine are used as local applications in solutions of one to four grains to the ounce.

IRRITANTS.

Powdered Calomel.—This is applied by dusting it into the eye with a camel's-hair brush. The brush should not touch the eye, and the powder should be very fine, lest it form lumps, which lie in the conjunctival sac, to act as foreign bodies.

Ointments.—These are usually made of the red or yellow oxide of mercury, of varying strength from $\frac{1}{2}$ to 2 grains to the ounce of cold cream, vaseline, benzoated lard, Simon's ointment, simple cerate, or similar agents. They are applied between the lids by a spatula, and by rubbing the lids act on the whole front of the eye.

Ointments are also largely used in ophthalmic practice, chiefly to lessen or prevent the lids from gluing together, in disease of the conjunctiva. They should always be a bland application, such as those that have been mentioned as vehicles for irritating applications to the eyes. Vaseline is also used as an application in purulent ophthalmia, when the eye is kept filled with it (F. M. Wilson, Bridgeport, Conn., 1888).

Jequirity.—The powder or solution of this bean is extremely valuable in bad cases of trachoma with vascular keratitis (pannus). A membranous inflammation of the lids is excited in a few hours, by placing a very small quantity, say $\frac{1}{120}$ of a drachm, upon the palpebral conjunctiva. It was used by the Indians of Brazil as a cure for trachoma, and introduced to the profession

by Wecker of Paris (nineteenth century). It has, without good reason. in many places fallen into disuse, but it remains one of the most useful of agents in trachoma attended by pannus.

EXCLUSION OF LIGHT.

Until within a few years, the general opinion seems to have been, both among the profession and the laity, that light, even ordinary daylight, is very harmful to any eye that has suffered an accident or is affected by disease. Accordingly ophthalmic patients were shut up in dark rooms, for the most trifling accidents and with diseases of a mild type. Among unintelligent people, the exclusion of light is often carried to still greater lengths, and heavy bandages and even blankets over the eyes and head are added to the dark room. Such patients have sometimes been excluded from all light by such means, for months and years. Among surgeons also, until recently, that is to say within ten or fifteen years, patients were much more rigorously treated with respect to the admission of light to their rooms, than they now are. There are very few cases in which a patient requires any more exclusion from the light, than can be obtained from a pair of tinted glasses, blue or London smoke, or by a shade, monocular or double, or a bandage. The bandage, however, is chiefly used to keep the lids closed and to secure union of the edges of a wound, to prevent prolapse of the iris, or bulging of the cornea. Ordinary daylight or even electric or gaslight, so used that no glare falls directly upon the patient's eye, may be admitted into the room in which he is, with impunity. In good weather, particularly in weather that is not windy, most eye patients are better off with exercise in the open air, except just after operations upon the cornea. The ophthalmic surgeon in all his treatment of local conditions, must never lose sight of the general condition of the patient. Many patients seek the exclusion of light, when to indulge their propensity would be ruinous.

ANTISEPTIC AND ASEPTIC PRECAUTIONS.

The discoveries of Pasteur (Paris, nineteenth century) and the clinical experiments of Lister (Edinburgh, nineteenth cen-

tury) called the attention of surgeons, after years of wonderful inattention, to the necessity of absolute cleanliness of the field of operation, the surgeon's hands and instruments, in all surgical procedures. By field of operation is meant not only the part to be operated upon, but also the room in which the operation is performed. Besides this, the clothing of the patient, the room in which he is put after the operation, the hands and apparatus of the assistants, deserve careful consideration and labor to see that they are kept clean. Whether morbid germs are the cause or consequence of purulent infection, certain it is, that there is nothing that can befall a surgical wound, or other injury, so harmful as a suppurative process. What is true of a failure to secure union by first intention in general surgery, is doubly true in the eye, when healing by first intention, notably in operations for cataract, is indispensable to secure a successful result. It is probable that chemical and mechanical influences have much to do, as well as infection by specific bacteria, in the production of suppuration. For example, the violent and frequent closing and opening of the lids by the patient after a cataract operation will displace the flap and invite suppuration, as will, what is known as dirt, should it get between the lids. A blow upon the eye, when all aseptic and antiseptic precautions have been faithfully and intelligently employed, will also destroy the effect of the best operation. Besides this, drugs improperly or accidentally applied may cause such a violent reaction or congestion of the blood-vessels, as to induce suppuration, primarily by chemical changes. Be all this as it may, there still remains a large proportion of cases in which suppuration is induced by the presence of septic material, such for example as from the bacillus of morbid lachrymal secretion (lachrymal catarrh), or that from the diseased conjunctiva. The patient's cornea may be infected from its own lachrymal or conjunctival secretion, or from that of others, conveyed by unclean instruments, or by an infected bed-chamber or operating-room.

Sometimes operations are performed with every local antiseptic precaution, and yet the law of absolute cleanliness of surroundings is neglected grievously. Operating-rooms should be constructed so that they may be absolutely and easily cleansed, the floor and the ceilings, tables, and chairs, with soap and water and antiseptic solutions. In patients' rooms all woollen hang-

ings as well as carpets should be dispensed with. In winter small rugs may be sparingly employed, while the nurses and friends of patients should wear clothing that can be washed, and not become carriers of contagion.

As to local antiseptic precautions, I am thoroughly content with such precautions as those that have been indicated, if, in addition, the instruments to be used are thoroughly cleansed in boiling water just before using, and then dipped in boiling water the instant before they are placed upon the eye. In addition, I wash the eye and surroundings with a saturated solution of boric acid; the patient, if about to have a cataract operation, having had a full bath the day before, or the morning of the operation. Most of my colleagues, however, to whose opinions I give great respect, use solutions of bichloride for cleansing the eyes before and after operations, and place vaseline and bichloride ointment upon the closed lids, and bichloride gauze over all. This I do not think to be necessary, and a possible irritant.

BANDAGES.

The protective and the compress bandage play an important part in the therapeutics of the eye. They are used in the one case simply to prevent injurious influences, such as wind and dust from affecting the eye, and also for keeping the lids closed. In the other case, the compress bandage is used to exert uniform pressure upon the eye and assist to maintain coaptation of the wounds of the lids or cornea. One of the best methods of closing the eye is first to apply vaseline, benzoated lard, or a similar lubricant along the edges of the lids, and then a bit of cotton cloth sufficient to cover the whole eye. The orbital space is then filled up with absorbent cotton. A great boon was conferred upon the profession and. through them given, to the public, when absorbent cotton was

FIG. 72.—BINOCULAR FLANNEL BANDAGE.

invented. This takes up fluids so freely and it is so soft a material that it makes one of the very best means of applying washes to the eye, of cleansing the eye, and so forth. The readiness with which it can be destroyed, also adds to its qualities as an aseptic agent. Patients who need to make applications to their eyes, or to clean them very frequently, ought to be recommended the use of absorbent cotton for this purpose. It has many advantages over ordinary cotton. Even the finest cotton wool used by jewellers for packing is inferior to it. The quantity used over the eye is according to the object desired by the use of the bandage. It is carefully distributed, so that the

FIG. 73.—MONOCULAR FLANNEL BANDAGE.

FIG. 74.—MONOCULAR PAD USED AFTER REMOVAL OF A BANDAGE.

pressure may be uniform. A flannel roller bandage is then applied over this (Graefe, Berlin, nineteenth century, 1851). This should be one and a half inches wide. It is applied by alternating turns, first around the forehead and then down under the occiput and over the eye, being fastened securely by pins.

Isinglass plaster has been lately recommended as an excellent means to be exclusively used in closing the eyelids (Chisholm, Baltimore). I have had a large experience with this means of closing the eyes some twenty years ago, when Agnew practised it almost exclusively. But the danger that the eye may suffer irreparable injury from want of sufficient protection, and the inconvenience in removing it, led me to follow Dr. Agnew's example and go back to the bandage.

A monocular pad, fastened over the head with tapes, is in

efficient means of protecting the eye of a convalescent patient, after an operation.

Eye Shades.—These are chiefly used as a protection from a glare of light or a wind. They are made of pasteboard covered by black or blue silk, and fastened by tapes running around the head.

Protective Spectacles.—These are of various tints of blue or London smoke. They should be of good glass, having no refractive power, or they are very unpleasant.

Local Blood-letting.—This is accomplished by natural and artificial leeches. They are applied to the temples about an inch from the outer canthus or further back among the hairs (which are first shaved) if it is necessary to hide the scar. The effect of the artificial leech is revulsive, and the vision is sometimes worse immediately after. After-bleeding from leeching should be encouraged by hot applications, and the patient kept in a darkened room for the ensuing twelve to twenty-four hours. Leeches are a most efficient agent in appropriate cases. They are not enough employed by general practitioners, on account, as it seems, of the alleged difficulty of securing and taking care of them. These difficulties are purely imaginary; they may be got in any number in the large cities, and kept in their native earth for an indefinite time.

CHAPTER X.

SURGICAL OPERATIONS ON THE EYE.

General Remarks.—Paracentesis of the Cornea.—Saemisch's Operation.—Trephining of the Cornea.—Iridectomy.—Corelysis.—Keratonyxis.—Extraction of Cataract.—Various Methods.—Accidents in Cataract Operations.—Strabismus Operations.—Operations for Lachrymal Stricture.—Canthoplasty.—Operations for Entropion and Ectropion.—Skin Grafting.—Plastic Operations.—Enucleation of the Eyeball.—Artificial Eyes.—Anaesthetics in Operations.—Ether.—Chloroform.—Light for Operations.—Operating Chairs and Tables.

AFTER the local and general precautions as to cleanliness and antisepsis, which have been described in the preceding chapter, the immediate matter in hand in an eye case requiring a surgical operation, is the proper method of its performance. Most practitioners who thoroughly train themselves may secure sufficient capacity for the successful performance of operations upon the eyeball. In order to do this, however, any one who proposes to operate should first secure the requisite manual dexterity, by operations very frequently repeated upon the cadaver. In operating upon the eye, unlike operations in general surgery, there is no opportunity to become steady by the preliminary cutting of the integument and other comparatively unimportant structures. At the first entrance of the knife into the tissue, notably in cataract operations and iridectomy, the operator by his want of steadiness and skill, may do irreparable harm. Most men with any surgical proclivities may overcome a little nervousness, causing tremor, by constant practice upon the cadaver. Those who cannot, and they are generally those who have no surgical tastes, should not undertake operations upon the eye itself, although such persons may be perfectly competent for operations upon the lids and tear-passages. Again, the operation for extraction of cataract is one requiring much special experience, the first of which should be under the direction of skilled masters. A practitioner with little experi-

ence under such teaching, should not undertake isolated cases, unless he has an especially good surgical aptitude, although it is not to be denied that practitioners who operate but very rarely, but who know well how to use surgical instruments, sometimes get excellent results. The eyes of pigs make excellent substitutes for human eyes in experimental operations, and operations should be rehearsed on them.

SPECULA.

The lids are held apart, when necessary, by a *spring speculum*, or elevators. I prefer the hinged speculum of Galezowski to

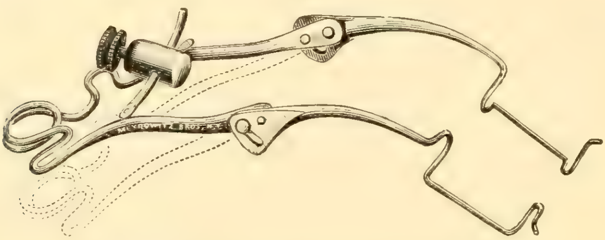


FIG. 75.—GALEZOWSKI'S SPECULUM WITH HINGE JOINTS.

any other for adults. There are many varieties of these essential instruments. The eyeball is kept in position by a *fixation forceps*, which should grasp a fold of conjunctiva near the corneal margin, and be lightly held, so as to steady the globe, without any undue traction or pressure. Most of the incisions are made through the

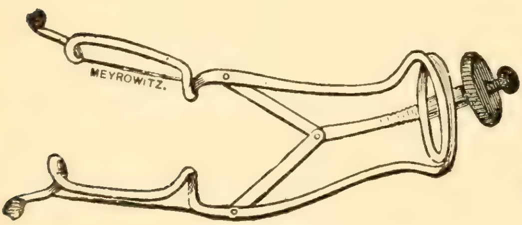


FIG. 76.—NOYES' SPECULUM.

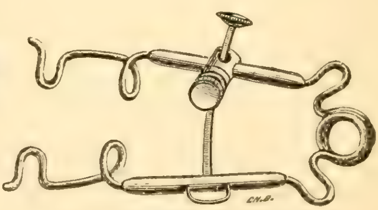


FIG. 77.—SPECULUM FOR THE EYES OF CHILDREN.

cornea, and the knife should always be entered perpendicularly, so as to divide the tissue by the shortest route, and not run between its laminæ. When the point of the instrument has entered the anterior chamber, it should be turned forward and carefully

watched lest it wound the iris or lens. Incisions in the ciliary region are to be avoided, on account of the risk of sympathetic ophthalmia. Blood-clots are best removed from the incision in

FIG. 78.—SPRING FIXATION FORCEPS.

front of the eye, by gently rubbing the lids over it or by fine forceps.

PARACENTESIS OF THE CORNEA.—This is performed by passing a needle or the blade of an iridectomy knife through the cornea near its margin, and allowing the aqueous humor to drain off slowly alongside of the instrument. In this and all other operations where the anterior chamber is opened, a too rapid escape

FIG. 79.—PARACENTESIS KNIVES.

of fluid must be avoided, through fear of prolapse of the iris, and of injurious shock, which results from too sudden diminution of the intra-ocular tension.

SAEMISCH'S OPERATION FOR INDOLENT ULCER (Saemisch, Bonn, nineteenth century) consists in passing the point of a narrow-bladed cataract knife through the healthy cornea, 1 mm. from one edge of the ulcer, and bringing it out the same distance from the opposite edge. The knife is then made to cut its way out through the bottom of the ulcer. The incision may be kept open by passing a fine probe through it every day or two, and the tension so kept down until the process of repair begins. This operation is also performed for corneal abscess.

TREPHINING OF THE CORNEA (Bowman, London, 1872) is done by an instrument specially designed for the purpose. A circular disc of corneal tissue is removed, Descemet's membrane being generally left behind if possible.

IRIDECTOMY (WENZEL, 1780).

(Greek *ιρις*, and *εκτομαι*, cutting out.)

The iridectomy knife is entered through the cornea near its border, carried on until the incision is of the desired length, and then withdrawn. Iris forceps are then passed through the incision, made to grasp the iris and draw it out, when the desired amount is cut off with scissors, close to the lips of the wound. A cataract knife, Graefe's, is often used for this operation.

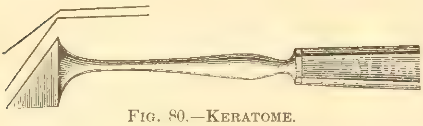


FIG. 80.—KERATOME.

Various forms of iris forceps are used by different operators. I prefer the small ones figured herewith, and known as Fischer's (Austria, nineteenth century), but the larger instruments are, perhaps, more commonly used.

FIG. 81.—FISCHER'S IRIS FORCEPS.

IRIDOTOMY (Greek, *ἰρις*, and *τομη*, section) (Cheselden, England, 1728).—This operation is chiefly performed where the iris has formed adhesions to the cornea or lens, and the pupil is closed by inflammatory deposit. The object of the operation is to make a slit in the iris, with the hope that its edges will retract, leaving a permanent opening, to serve as a new pupil. Sometimes the slit is made simply by a knife passed through the cornea and iris (Loring, New York). Special instruments have been devised for the operation, such as the scissors of M. de Wecker (Paris, nineteenth century). The cuts

FIG. 82.—NARROW GRAEFE KNIFE.

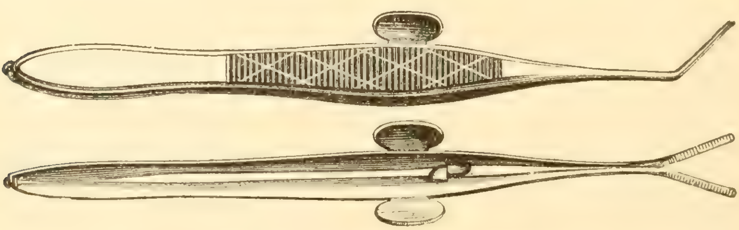


FIG. 83.—WECKER'S IRIDOTOMY SCISSORS.

show Wecker's scissors for iridotomy. I prefer a narrow cataract knife or Galezowski's sickle-shaped knife for an iridotomy to the scissors.

CORELYSIS (κορη, *pupil*, and λυσις, *loosing*) (Wenzel).—This is performed to break up adhesions, which have formed between the iris and the capsule of the lens. An opening is made near the corneal margin, a little to one side of the adhesion which it is proposed to loosen. A blunt flattened hook is then passed in and made to tear through the attachment (Streatfield's method); or, an incision having been made near the edge of the

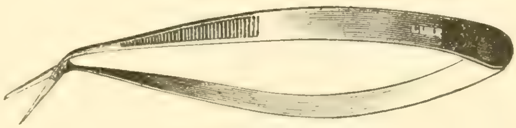


FIG. 84.—IRIS SCISSORS.

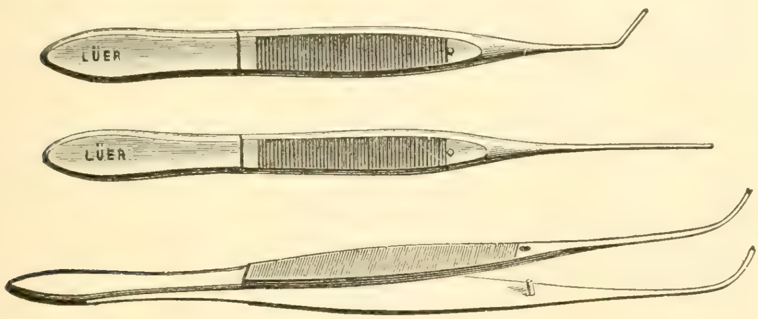


FIG. 85.—IRIS FORCEPS.

cornea, the iris is grasped by a pair of curved forceps, near the adhesion, which is then loosened by traction made toward the periphery (Passavant's method).

OPERATIONS FOR CATARACT.

KERATONYXIS.

(κερας, cornea, and νυσσω, to puncture.)

DISCISSION OR SOLUTION OF CATARACT (Conradi, Germany, 1797).—This operation is applicable only to soft cataracts. It consists in lacerating the anterior capsule by a fine needle, passed in through the peripheral portion of the cornea. The aqueous humor thus comes in contact with the lens matter, and softens

it so that it is gradually absorbed. The operation usually must be repeated several times. It is best to lacerate the capsule and the lens very slightly, especially at the first operation, else great swelling of lens matter may result, causing injurious pressure (secondary glaucoma). The pupil should be dilated with atropine before the operation.

Soft cataracts are also removed through a *linear incision*, made with an iridectomy knife at the edge of the cornea. The most of the lenticular substance may escape spontaneously as soon as the wound is completed, or it may require to be coaxed out in same manner as hard cataracts, or to be removed by a curette. When there is great swelling of the lens after keratonyxis, it should be evacuated at once through a linear incision. Soft cataracts are sometimes evacuated by *suction*. A suction instrument has been devised for this purpose, which can be passed through a small opening in the cornea.

REMOVAL OF CATARACT BY SUCTION.

The operation of removal of cataract by suction has not, perhaps, received sufficient attention. It is an operation re-introduced by Mr. Pridgin Teale, Jr., of Leeds, England, who suggested it and performed it with success in December, 1863, on a young man who had a traumatic cataract.[1] Mr. Teale was quite unaware, at the time, of the antiquity of the operation. He did not know that it had ever before been practised, but he found that a similar proceeding was practised by the Persians in the fourth century, and in an American edition of Lawrence's "Treatise on Diseases of the Eye," 1854, p. 1,733, M. Blanchet is quoted as performing the same operation, *par suspiration*. Mr. Teale improved on the operation by using a glass tube, to one end of which is fastened a tubular curette, while to the other extremity a piece of India-rubber tubing with a glass mouthpiece is attached. In the operation the capsule of the lens is first torn with a fine needle, the lens matter having been broken up so that every part of it is freely exposed to the action of the

FIG. 86.—SUCTION APPARATUS REDUCED IN SIZE (H. Derby).

[1] "Lectures on the Eye, Orbit, and Eyelids," Lawson. London: Longmans, Green & Co., 1867, p. 154.

aqueous humor, and then the whole lens is removed through the tubular curette, the mouth of the operator being the suction power. Mr. Lawson divided the operation into two stages, the second stage being performed two, three, or four days after the wounding of the capsule. An opening is made in the cornea with a broad needle immediately within the pupillary margin of the dilated pupil, sufficient in size to allow of the easy entrance of the tubular curette. The instrument is, of course, to be managed in the most delicate manner. The suction may also be performed by a cataract syringe, —a delicate metal syringe placed at one extremity of a glass tube, the other end having a tubular curette. The syringe is so contrived that the piston can be worked with one hand and the movements of the curette guided, while the other is left free to fix the globe with a pair of forceps. Dr. Derby performs this suction operation[1] by means of an instrument made from the glass barrel of an ordinary subcutaneous injection syringe, to one extremity of which is attached a piece of rubber tubing ending in the mouthpiece, while on the other is a bent hollow needle of large size (see Fig. 86). This needle is passed through a small opening in the cornea and anterior capsule. The air in the tube is then exhausted, and the cataract substance flows in to take its place. This is substantially Teale's method of operation. The instruments for this operation are a spring speculum, fixation forceps, broad needle, and the suction apparatus. The barrel is shorter and less in diameter than the English instrument. The neck of the hollow needle at its lower end fits the opening made by the broad needle, and the opening is across the extremity instead of being on its front face. The rubber tube that connects with the mouthpiece has a coil of light wire running the entire length of its interior. The modifications of the instrument are largely due to Dr. Robert Willard, of Boston.[1]

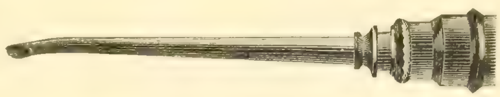


FIG. 87.—MAGNIFIED PICTURE OF POINT OF SUCTION INSTRUMENT (H. Derby).

In 1885, 107 operations by suction had been performed at the Massachusetts Charitable Eye and Ear Infirmary. In the 65 recorded cases, full success was accomplished in 46, partial in 18, and loss in one. Although this is an operation deserving of more consideration than it has generally received, I do not think it has many advantages over a good linear extraction, while it is rather more difficult to perform.

[1] "Reference Handbook," Article "Cataract," vol. i., page 798.

A syringe, Panas', or a simpler one, an ordinary dropper or Lippincott's may be used for washing out the remains of a soft

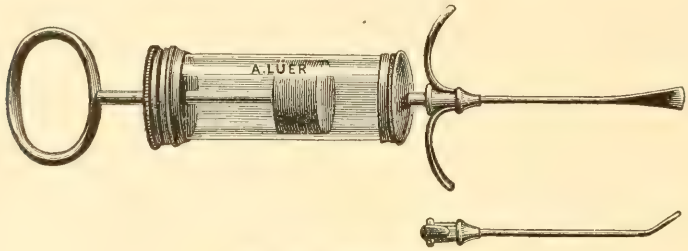


FIG. 88.—PANAS' SYRINGE.

lens, as well as the cortex often left behind in the extraction of hard cataract.

EXTRACTION OF CATARACT.

The operation of extraction is designed for the removal of hard cataracts. It has long since supplanted the old and dangerous operation of *reclination* or *couching*, by which the lens was pushed down into the vitreous humor and left there. The chief credit of introducing extraction is given to Jacques Daviel (France, 1745). A statue has been erected to him in France.

Simple flap extraction is now performed by a section made with a narrow knife either upward or downward, far preferably upward, at the margin of the cornea, so that about half the cornea is comprised in the flap. The capsule is next opened by a cystotome. Then gentle pressure is made with the finger or a curette, against the globe opposite the flap, and upon the globe, so as to tip the edge of the lens forward into the wound, through which it escapes. No iridectomy is performed in this operation.

Graefe's modified linear extraction (Albrecht von Graefe, Berlin, died 1870), itself greatly modified since he first proposed it, was for years the most common operation for hard cataract. The incision is smaller than in the flap operation, and may be regulated by the size and hardness of the lens. The operation is usually performed somewhat as follows: The point of a narrow-bladed knife (*a Graefe knife*) is passed through the

FIG. 89.—GRAEFE KNIFE.

cornea, just beyond the limbus, and a little above its centre, carried across the anterior chamber, and out at a corresponding

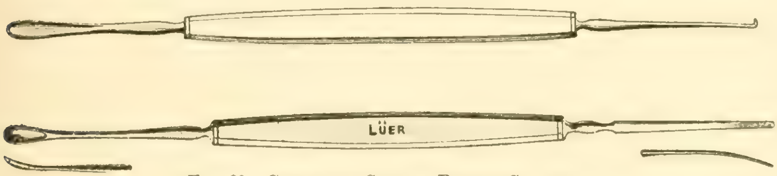


Fig. 90.—Cystotome Spoon. Rubber Spatula.

point on the opposite side. The first puncture is made with the point of the knife, directed downward toward the centre of the pupil, so that the inner lip of the wound may be as large as possible. After completing the puncture and counter-puncture, the edge of the knife is turned obliquely upward and forward, and by a sawing motion made to cut its way out, emerging about at the upper sclero-corneal margin. A piece of iris is drawn out and excised. The capsule is divided by the cystotome, preferably by a T-shaped incision, or by an incision along the periphery. The lens is tipped forward into the track of the wound, generally by pressure with the curette at the opposite corneal margin, or with the finger; then by gently sliding the curette over the cornea, the lens is forced out. The incision is made either upward or downward, preferably upward.

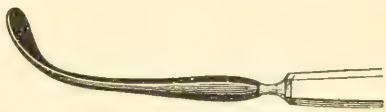


Fig. 91.—Rubber Spoon.

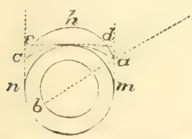


Fig. 92.—Ideal Peripheric Linear Section. Ideal peripheric linear cut, corneal diameter 12 mm., *am*, *cn*, tangents to the horizontal diameter *mn*; *de*, tangent to the vertical diameter; *a*, point of puncture; *a*, *b*, line of direction of back of knife at time of puncture; *c*, point of counter-puncture; *a*, *d*, *h*, *e*, *c*, course of conjunctival wound; *a*, *c*, course of corneo-scleral wound on outer surface of sclera.[1]

Graefe's first operation was begun and ended in scleral tissue; although this, like all of Graefe's suggestions, at first received almost universal commendation, it was soon abandoned on account of the obvious invitation to sympathetic inflammation of the fellow-eye, and a section entirely in the cornea substituted (see chapter on Cataract). The lens may also be extracted in its capsule by dislocating the lens with the back of the knife after making the counter-punc-

[1] From "Reference Handbook Medical Sciences," Hasket Derby, vol. i., p. 801.

ture. It is then evacuated in the usual way (Roosa, New York, 1880).

Another method of extraction of the lens in its capsule is to make a downward section and remove it with a curette (Pagenstecher, Wiesbaden, 1872).

Liebreich's Operation (Liebreich, London).—The incision in this operation is made with a narrow-bladed knife. It is more transverse than in Graefe's operation, lying wholly in the

Fig. 93.—Extraction of Cataract (After a Photograph). This picture is more realistic than the others, but it presents a clear view of making a section in an ordinary simple extraction.

cornea, except the puncture and counter-puncture, which are made in the sclerotic about 1 mm. from its edge. No iridectomy is performed.

Preliminary Iridectomy.—A cataract extraction is sometimes divided between two operations. At the first, an iridectomy is performed; then at some subsequent time the lens is removed. This is called Jacobsen's method (Jacobsen, Königsberg, 1866). This operation is also generally modified by making an incision entirely in the cornea.

OPERATIONS FOR *secondary cataract*, or membranes, consist usually in making a small hole through the membrane by tearing it with needles (called a *needling*) or forceps, or by cutting it with a knife or special form of scissors.

FIG. 94.—GALEZOWSKI'S CYSTOTOME.

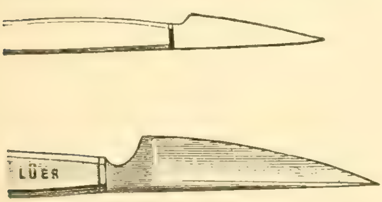
Galezowski's sickle-shaped knife, Knapp's knife needle, or a narrow iridectomy knife (Loring), or Wecker's scissors may be used for iridotomy, according as the nature of the case or the surgeon's views may decide. I use either a Galezowski or a

FIG. 95.—HOOK-SHAPED CYSTOTOME.

FIG. 96.—CYSTOTOME.

Graefe knife in all the iridotomies and operations for membranous or secondary cataract that I perform.

SIMPLE EXTRACTION.—At the present time in New York, the operation most frequently performed for hard cataract is simple extraction. This is a flap operation, the flap being made with a narrow knife, and without a coincident iridectomy. The capsule is then divided with a capsulotome, and the lens extracted by the fingers or the spoons. This is essentially a return to the classical operation of Beer, except that instead of the triangular knife of Beer (Figs. 97, 98), the narrow and much more convenient knife of Graefe is used.



FIGS. 97 AND 98.—BEER'S KNIVES.

POSSIBLE ACCIDENTS IN THE OPERATION OF EXTRACTION OF CATARACT.

1. The iris may fall before the knife and be cut. This is not a serious accident, the operator may go on as if it had not occurred.

2. The operator may enter the knife improperly, so that the back presents instead of the edge. This is of course a piece of carelessness, yet the knives are so thin and narrow that even experienced operators have been known to make this mistake.

Should it occur, the knife may be withdrawn, the operation deferred for a day, or until the corneal wound has healed, or the cut may be made in the opposite direction, the knife being turned while in the eye.

3. The incision may be made too small, so that the lens escapes, if at all, with great difficulty. As soon as it is seen that the lens will not readily escape, for this reason, the corneal flap should be enlarged with the scissors. This is by no means an accident fatal to the eye, but it is a dangerous one, because it makes an uneven flap, that may be very slow in healing. Yet some excellent results have been obtained after this accident.

4. The vitreous may escape before the lens can be evacuated, and the lens may then fall back into the vitreous humor. This is a bad accident. A spoon is to be introduced at once, and the lens removed, if possible. If this cannot be quickly done, the eye should be closed, healing of the wound secured, and a subsequent attempt made to remove the lens. A subsequent attempt is usually successful. The loss of considerable vitreous, say one-third its volume, is not necessarily fatal to the success of a cataract operation, but it is an unfavorable occurrence. It may be followed by a detachment of the retina, and by intraocular hemorrhage. Yet excellent results often follow operation with considerable loss of vitreous.

5. Prolapse of the iris, or incarceration of the iris in the wound. If this occur during the operation, and it is not easily replaced with a hard rubber spatula, the iris should be cut off. But if it occur during the healing, it is better to leave the shrivelling of the prolapsed iris to nature.

This is also a bad accident unless the iris can be at once cut off smoothly. Incarceration of the iris, with the leaving behind of a thick mass of capsule, may lessen the filtration angle and be the cause of glaucoma.

6. Incomplete removal of the lens matter. This is a troublesome thing at times. Efforts should be made, by massage of the closed lids, by gentle use of spoons outside the eye, and the syringe in the anterior chamber, to leave a black pupil, and an ability on the part of the patient to count fingers; but when there is danger of much loss of vitreous it is better to take the chances of absorption of the lens matter.

STRABISMUS OPERATION.

TENOTOMY—STRABOTOMY (Dieffenbach, Germany, 1839).—A speculum having been placed in the eye, a fold of conjunctiva and subconjunctival tissue is seized with the forceps near the margin of the cornea, and over the insertion of the tendon to be divided. This fold is snipped with blunt-pointed scissors, curved on the flat, which are then passed into the opening by a burrowing motion, and made to thoroughly divide the subconjunctival tissue about the insertion of the muscle. The strabismus hook is inserted and passed under the tendon so as to catch it up, after which it is brought into view by pushing aside the conjunctiva. While held on the hook, it is divided with scissors close to its insertion. The cutting of the muscle should begin at the distal end of the hook. Another hook is then inserted and moved freely around, and any remaining fibres caught up and divided in same way. There are several minor modifications of this method of operation. The wound in the conjunctiva is united by sutures when desired.

FIG. 99.—STRABISMUS HOOK.

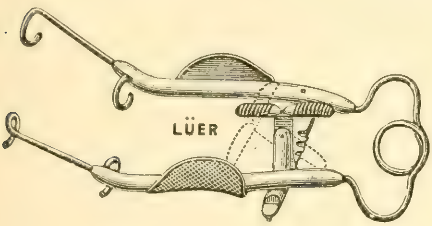


FIG. 100.—SPECULUM.

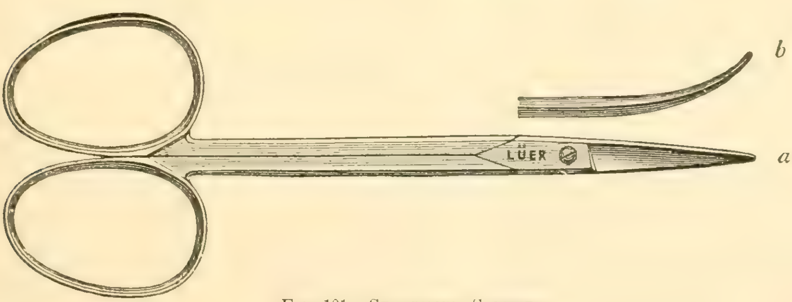


FIG. 101.—STRABISMUS SCISSORS.

It adds to the comfort of a patient after a strabismus operation, to apply iced cloths to the eye for a few hours. If the patient be operated upon away from his own home, or he is not

in a hospital, the eye should be bandaged on his going out into the air, and remain so until he is within doors, when the bandage is to be removed. Severe inflammation in a few cases, destructive in character, has occurred after tenotomy, from infection of the wound from improper care, or want of care.

FIG. 102.—FIXATION FORCEPS.

Cases[1] have been reported in which the operator has divided the sclera and entered the vitreous, in the too free use of the scissors in separating the muscle from its attachment.

In two cases, which Dr. Hasket Derby saw, although he was not the operator, the wounds healed, without damage to vision,

FIG. 103.—FORCEPS FOR SEIZING THE CONJUNCTIVA.

although in one case convalescence lasted nearly six weeks. The wound healed very slowly. It was feared it would open and vitreous escape as late as the eighth day. In the second case three weeks were required for the healing of the wound. In both of these cases the operators confessed that the scissors were not what they should be; the pair used in the first case was straight and thick, the pair employed in the second case, was dull. Alfred Graefe is, therefore, probably right in attributing the accident to want of dexterity, or, as I would prefer to say, to want of punctilious attention to detail in the preparation for, and performance of, any surgical operation. In the discussion that followed this paper, Knapp stated that in three thousand operations, he had perforated the sclera three times. In two cases, it was because an assistant gave him sharp-pointed scissors instead of blunt ones. Dr. E. Williams also once suffered this accident. Dr. Buller thought the mishap one liable to occur to the most skilful operator. He had seen the accident twice. In both instances the patient had done well. The conjunctiva was stitched in the cases which Dr. Buller saw. A case was reported in which panophthalmitis had occurred as a result of the perforation of the sclerotic.

[1] Transactions American Ophthalmological Society, 1885, page 33.

From all this, the young operator will certainly be sufficiently warned, never to use dull or sharp-pointed scissors in a strabismus operation.

Inflammation of the capsule of Tenon after a strabismus operation may occur as a result of a violent use of the hook, or from infection of the wound.

LACHRYMAL OPERATIONS.—BOWMAN'S OPERATION FOR OPENING THE CANALICULI.—PROBING THE NASAL DUCT.

(Bowman, London, nineteenth century.)—A fine director is passed into the punctum and along the canaliculus into the lachrymal sac, its grooves being turned toward the free margin of the

FIG. 104.—BOWMAN'S LACHRYMAL PROBE.

lid, which is kept tense by being pulled outward with the finger. The point of a narrow-bladed knife is then inserted into the punctum, and passed along the canal, so as to lay it open quite into the sac. Or a narrow, probe-pointed knife is passed into the punctum and along the canaliculus, which is divided by raising

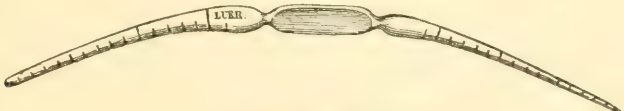


FIG. 105.—WEBER'S PROBE.

the knife from heel to point, no director being used. The latter is the more common method. Sometimes the knife is passed onward through the nasal duct for the purpose of dividing strictures. Yet the beginner will find a thorough preliminary

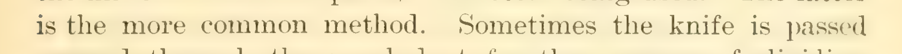


FIG. 106.—DIRECTOR AND CANALICULUS KNIFE.

dilatation a good preparation both for the steadiness of the patient, to whom the dilatation gives very little, if any, pain, and for the successful cutting of the little canal.

Probing the nasal duct is done by Bowman's probes, which are of different sizes and bent to correspond with the

course of the duct. The end of the probe is passed along the divided canaliculus, until it is felt to strike hard upon the inner wall of the sac. It is then raised into a vertical position with the convexity of its bend backward, and passed downward through the sac and then downward, outward, and forward through the duct into nose. When the end of the probe is not in the sac each movement of it will be seen to cause a movement of the underlying skin, and it will not give to the finger the sensation of striking against the firm, bony wall, as it does when in proper position. If the treatment by probing the nasal duct is to be successful, a thorough division of the canaliculus into the sac is essential.

Fig. 107.—Probe in Position.

The exact manner of passing lachrymal probes, the amount of force to be used, and so forth, can only be acquired by experience. This should be had on the cadaver.

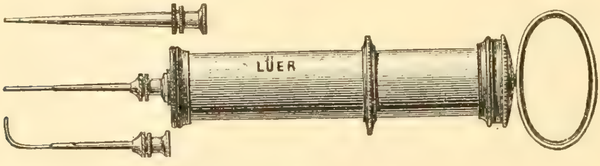


Fig. 108.—Anel's Syringe.

A hollow probe (Wecker, Paris) is sometimes used and injections made through it along the whole nasal duct, withdrawing it gradually as the syringing goes on.

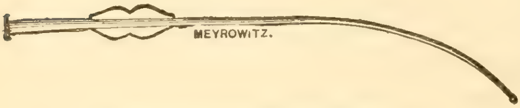


Fig. 109.—Hollow Probe, Wecker.

Some surgeons prefer bulbous probes (H. W. Williams, Boston); others still employ styles or probes which may be left in for weeks (see Chapter on Diseases of Lachrymal Apparatus); others em-

ploy tapering probes, like that here figured, but I recommend the original probe as advised by Bowman. In rare

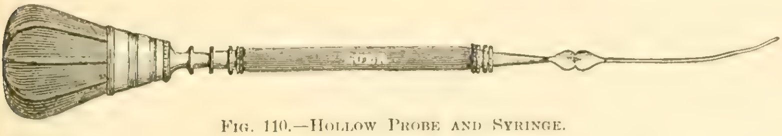


FIG. 110.—HOLLOW PROBE AND SYRINGE.

cases, I find it necessary to go beyond the sizes recommended by Bowman.

BRINGING FORWARD OR ADVANCEMENT OF THE INSERTION OF A MUSCLE.

An incision is made in the conjunctiva, one to two lines from the edge of the cornea and over the tendon of the muscle. The tissues including the muscle (whose insertion is first separated from the globe) are dissected up from the sclerotic as far back as the equator of the eyeball. The flap thus formed is pulled forward and united by sutures to the flap left standing at the corneal margin, so as to cause the tendon to unite itself with the sclerotic at a point farther forward. Sometimes a piece of muscle is excised so as to shorten it. If some conjunctiva is excised before bringing the flaps together, the effect is increased. The tendon of the opposite muscle is usually also divided to increase the effect. The operation is modified in several ways by different surgeons. In Agnew's method, which I usually practise, the muscle to be advanced is taken up with a hook having an eye in its distal portion. In this eye a thread is placed, with which the muscle is surrounded. The hook is withdrawn so as to leave the thread around the muscle, which is then tied. The muscle is carefully separated from the conjunctiva and connective tissue as well as from the capsule. After the opponent is divided the separated end of the muscle is quilted under the conjunctiva above, just at the situation of the superior rectus, and below at that of the inferior rectus, and attached. The conjunctival wound is closed by a suture, and the thread surrounding the muscle cut off. These threads may be left in the wound indefinitely, for they cause no irritation. They should be black in color.

The method of Dr. Prince (Indiana, 1886) has found much favor among surgeons, but after having performed the operation several times, I do not find that it has any advantage over that of Agnew, while it consumes more time in its performance. In Prince's operation, what the author terms an anchor or pulley suture, is first introduced into the tissue one millimetre from the corneal margin. The conjunctiva and the capsule of Tenon are then divided, and the tendon is grasped with a pair of forceps instead of a hook. The tendon is then separated from the sclera. A thread, each end of which is armed with a needle, is then passed from beneath the rectus muscle through the capsule, muscle, and conjunctiva. The middle portion of the muscle is thus enclosed in a loop. The tissues held by the forceps are now divided ten millimetres anterior to the loop suture. One end of this is now turned over the anchor or pulley suture. Both ends of the former are brought together and tied, enclosing the latter in a loop or pulley. Both ends of the double-armed thread are now brought together in a surgical knot. According as they are tightened over the pulley, the cut end of the rectus will be advanced. At the same time this closes the wound in the conjunctiva. A bow-knot is first tied, as traction is to be avoided during the operation. This knot may afterward be secured, and its effect increased or diminished.

Berry[1] modifies this operation by running the pulley suture in and out two or three times, over a larger extent of the circumcorneal conjunctival tissue. This gives it a better hold. The other suture is passed single instead of double, and farther back through the muscle than through the conjunctiva. The muscle must, therefore, be first freed somewhat in Berry's method. The portion of tendon grasped by the advancement forceps is cut off, and the bow-knot is discarded as not being essential. Berry performs the operation without an anæsthetic. The thread is pulled sufficiently tight to temporarily exaggerate the effect. An anæsthetic, except a local one, cocaine, is not necessary in advancement, if the operation is performed on persons having a fair degree of self-control. The effect should always be exaggerated, if possible, at the time of the operation in all advancements.

[1] "Diseases of the Eye," Philadelphia, 1893, p. 701 *et seq.*

CANTHOTOMY—CANTHOPLASTY.

(κανθος, the angle of the eye ; τεμνω, I cut.)

Division of the External Canthus.—The eyelids being well separated by a speculum, one blade of a pair of straight, strong scissors is passed behind the commissure down to the bottom of the *cul de sac*, and the other blade in front, and the commissure divided by one sharp cut, the incision being exactly horizontal. The conjunctival surfaces of the wound, are then joined to the cut edges of the skin by three or four fine sutures, one above, one below, and one at the outer angle being usually sufficient. After making the first incision some authorities recommend that the upper lid be put on the stretch, by pulling it toward the nose, and then that the upper canthal ligament be divided by a nick with the scissors at right angles to the incision, the nick being made about two inches in front of the temporal border of the orbit (Agnew, New York). A simple incision of the canthus, without sutures, is more properly called canthotomy.

OPERATIONS FOR DISTICHIASIS AND TRICHIASIS.

(*Entropion.*)—The most common and an excellent one is the *Jaesche-Arlt* (Jaesche, Russia; Arlt, Vienna, nineteenth century) operation or a modification of it. A horn spatula is placed under the upper lid, and by traction on the skin the edge of the lid is rolled upward and outward. An incision is made along the edge of the lid, from near the punctum lachrymale to the outer angle, dividing it into two layers, the outer containing the cilia and their bulbs, the inner the conjunctiva and cartilage. The incision is about one-sixth of an inch deep. A strip of skin somewhat crescentic in shape is then excised from just above the margin of the lid, and running its whole length. The edges of the wound are united by sutures, and this rolls the anterior lip of the split border, containing the eyelashes, outward. Sometimes a strip of orbicularis muscle, and a wedge-shaped piece of the cartilage, are excised with the fold of skin. The bridge of skin containing the lashes is sometimes separated from the underlying tissue, so that it can be moved upward and so

transplanted to a higher point, as the edges of the wound in the integument are drawn together. A canthoplasty is often performed in connection with the splitting of the lids. Other operations are also done for this deformity. The operations for

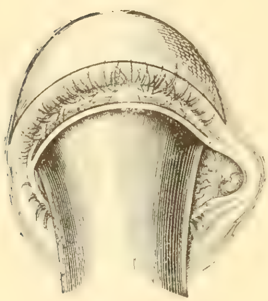


FIG. 111.—JAESCHE-ARLT OPERATION (INSERTION OF SPATULA).

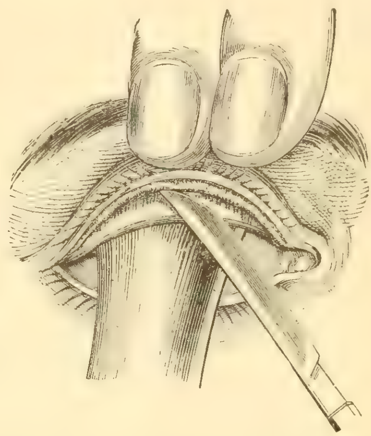


FIG. 112.—JAESCHE-ARLT OPERATION (SEPARATION OF CARTILAGE).

ectropion are numerous, and vary with the special requirements of the case.

The latest and perhaps the best modifications of the Jaesche-Arlt operation consist essentially of, first, an incision through the conjunctiva, just back of the cilia, well down to the cartilage; second, excision of a narrow bit of integument; third, the insertion of deep sutures from the conjunctival side (John Green, St. Louis; Hotz, Chicago).

In performing this operation, I employ only a spatula and the necessary knives and scissors. A Beer's cataract knife is extremely well adapted to splitting the lid, and cutting out the skin, but of course an ordinary scalpel will do very well.

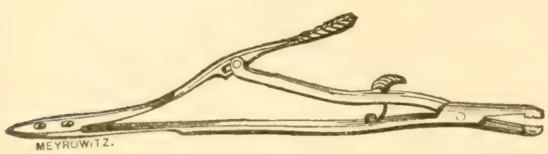


FIG. 113. SANDS' NEEDLE-HOLDER.

Distichiasis and trichiasis are often defined as conditions in which the lashes only turn inward, while the surface of the lid is in a normal position (Stellwag, Vienna, nineteenth century).

As a matter of fact, these conditions are usually associated with true entropion, and hence the difficulties in obtaining a good result are very great. When only a small part of the ciliary border is involved, that is, only a few hairs turn in, the Jaesche-Arlt operation may be performed, but in a circumscribed form as shown inthe figures.

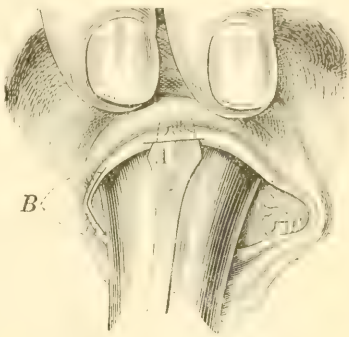


FIG. 114. OPERATION FOR PARTIAL TRICHIASIS.

In Fig. 114 the lid is split with an iridectomy knife, and the affected cilia are removed entirely. This may be performed as a supplementary operation when a previous one has left some cilia still turning inward.

The destruction of the hair-bulbs by electricity will be discussed in the section devoted to this subject.

The treatment and operation for true or complete entropion, that is to say, when the whole lid turns outward, will be discussed under the Consequences of Conjunctivitis, and Blepharospasm.

OPERATIONS FOR ECTROPION.

(ἐκτροπη, a turning from.)

A slight turning out of the lower eyelid especially may often be corrected by simply cutting out a triangular piece of the lid and uniting the gap by sutures. More extensive inversions will require more important operations, the nature of which can only be determined by the individual case. Narrowing of the palpebral fissure does good service for some cases. The surfaces of the edges of one or both canthi are freshened, without involving the cilia, and united by suture. But the simple narrowing of the palpebral fissure is insufficient, in cases with elongation of the free margin with stretching and relaxation of the fibro-cartilage.

FIG. 115.—ECTROPION.

For such cases the following operation may be performed: The lids are closed, and the lower one is brought into proper position, then the border is put slightly on the stretch horizontally. We should then mark with ink, in a vertical line, the two points of both edges of the lids, when both lid margins fit each other, when they are in a normal position. While the lids are kept in this position, the integument over the outer canthus is lifted up in a horizontal fold, and as much of the skin of the lower lid, as is necessary to bring it into a normal position, is very gradually fastened between the fingers. Then the excision of the portion of integument between the described boundaries is begun where it is indicated by two lines parallel to the edge of the lid.

FIG. 116.

A spatula (see Fig. 112) is pushed under the outer canthus. It is lifted away from the globe, and split into two layers with a Beer's knife. The wound on each side is enlarged with a scalpel or scissors. The margins of the lids are then freshened inward from the vertical boundary line for one-half to three-quarters of a line. The whole breadth of this incision falls behind the lashes. The lower border of the lid is now cut through in the vertical boundary line, down to the cartilage, and the incision extended until the horizontal line has been reached. The knife is then carried on parallel to the margin of the lid, and beyond the canthus is turned upward in the shape of an arch (see Fig. 116). The upper lid is treated in the same way. The integument is then dissected up and the wound closed by three or four sutures (Ammon, Graefe).[1]

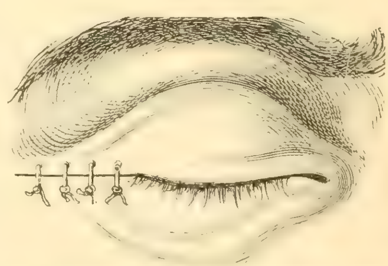


FIG. 117.—OPERATION FOR ECTROPION (SECOND STAGE).

[1] Stellwag: English translation by Roosa, Hackley, and Bull, p. 481.

Another operation is the following. The lid is first split from the lachrymal puncture to the outer canthus. Two vertical incisions, from 8 to 10 lines long, are then made through the integument. The quadrangular flap thus formed is then separated. It is then drawn up tightly, and united to the lateral incisions by sutures, beginning from below upward.

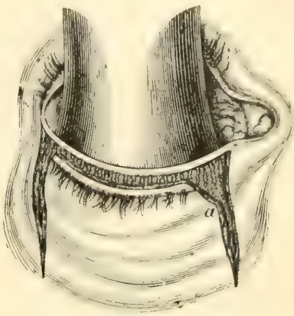


FIG. 118.—OPERATION FOR ECTROPION.

In order to correct the lengthening of the margin of the lid, the flap is supported by an incision, Fig. 118, *a*, which unites the inner with the horizontal edge of the flap. The intermarginal edge is also united by sutures. A bandage is then applied.

This operation is especially effective when the free border of the lid in much distorted, and when the conjunctiva is drawn over the anterior surface of the tarsal cartilage. Afterward an operation upon the angle of the lids may also be required (Graefe).[1]

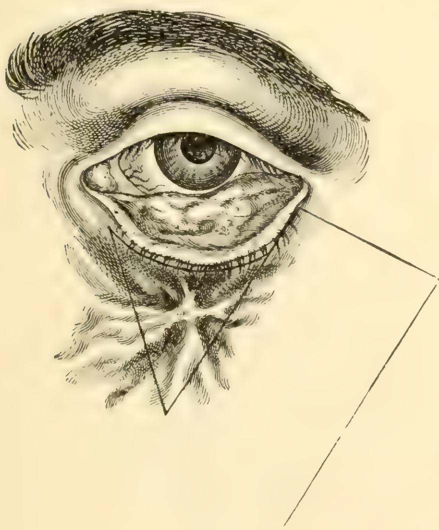


FIG. 119.—OPERATION FOR ECTROPION.

A plastic operation by which a triangular flap of integument is formed, is also sometimes useful. This is called Samson's operation. It is effectual when the margin of the lid is merely lengthened, without being changed in shape. The flap is formed by two straight incisions of the integument, a spatula being under the lid. The flap is made to include all the shrunken portion of the skin, if possible. When the flap is dissected up, the lid is easily brought into a correct

[1] Stellwag, *loc. cit.*, p. 483.

position. The flap will, however, cover only a part of the wound. There will remain a portion uncovered like a pointed arrow-head. This is covered by drawing the edge of the contiguous integument together. The outer borders of the vertex of the incision are first united by suture, then the remainder.[1]

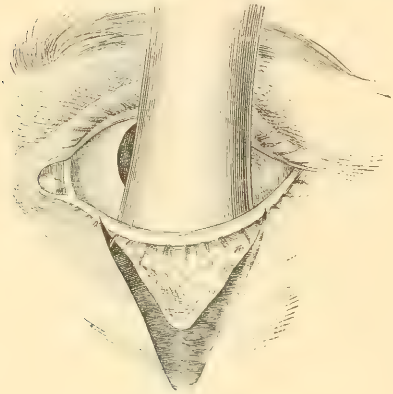


FIG. 120.—SAMSON'S OPERATION.

A small and deep cicatrix in a lid, causing ectropion, may be cut out and the ectropion thus cured. In such cases a crescentic incision is made, parallel to the edge of the lid. If a large portion of the lid be involved in the cicatrix, the cicatricial tissue may be cut out and a flap be transplanted from the adjacent integument. In all such plastic operations, it is of the highest importance to take the flap from healthy skin, and that a well-nourished bridge of tissue be secured. The method of operation will vary much in individual cases, according to its character and the ingenuity of the surgeon.

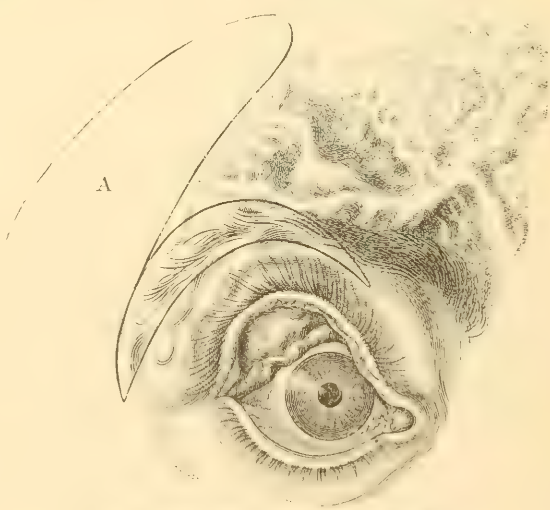


FIG. 121.—PLASTIC OPERATION (ARLT'S).

Fig. 121 is from one of Arlt's cases, quoted by Stellwag.

1. The cicatrix was first included in two curved and oblique incisions. After the cicatrix was dissected out, the wound was closed by the flap A. This was taken

[1] Stellwag, *loc. cit.*

from the antero-temporal region, and has an oblique axis. The anterior boundary line of this flap was united with the lower border of the incision in the lid while the posterior incision diverged somewhat, and ended under the level of the upper border of the surface of the incision in the lid. The cicatrix was then separated up to the inner border of the flap, which was turned upon the surface of the wound and united by sutures.

When the cicatrix causing the ectropion is small, it may be circumscribed by two elliptical incisions, the sides of which are to be as nearly as possible perpendicular to the border of the lid (Fig. 118, *a*). The surface of the cicatricial tissue is then freshened, the adjacent integument and fat well separated from the bone, so that the lid may be brought into a normal position, without stretching. The edges of the elliptical incision are then united by a suture, so that the whole cicatrix is covered over by the adjacent integument, and united to its posterior surface.

In broad adhesions, an incision is made parallel to the orbital margin, down to the bone, so that the skin and cicatrix may be well separated, subcutaneously, from the layer beneath, and the lid brought to its normal position. The palpebral fissure is then narrowed to the extent of a third or more by freshening its edges, and uniting them by suture. After the wound has completely united, and danger of shrinking has passed, the palpebral fissure may again be enlarged. Both of these methods of operation were described by Ammon (Berlin, 1842), in his treatise on "Plastic Surgery," and given by Stellwag.[1]

AFTER-TREATMENT OF PLASTIC OPERATIONS.

I do not advise the use of iodoform or solutions of corrosive chloride of mercury after plastic operations, but a dry dressing of absorbent cotton, to keep the parts well protected, and then a well-applied flannel bandage. The sutures may be reinforced by adhesive plaster, if any suspicion of undue tension exist. The bandage should not be reapplied, or at least the dressing, for some four days, unless there is positive evidence that healing by first intention is not going on properly. The thermometer here,

[1] *Loc. cit.*, p. 486.

as in operations for cataract extraction, if carefully noted, will assist in determining how the healing is progressing.

WOLFE'S METHOD.

Skin-grafting, of which general surgeons make so much use, since its introduction as a procedure for covering large cicatrices, by Reverdin, has also been availed of by ophthalmic surgeons, in ectropion caused by cicatrices. When there is no healthy skin in the immediate neighborhood, the plan of the Italian surgeon, Gasparo Tagliacozzi (Bologna, 1579), of taking a flap from the arm, and binding the arm in the part desired, the pedicle being always attached, may be employed.[1] It is said that it is usually not necessary to keep the arm in this position more than forty-eight hours, but forty-eight hours is an interminable period to an ordinary patient. It requires great will-power and strength of character, to cause a patient to submit to such a procedure. This method is, however, still practised, and with good results. Dr. Richard H. Derby[2] reports a striking case of success.

Mr. Wolfe (Glasgow, 1875) has done much to introduce the method of transporting a very thin piece of skin from a remote part, and applying it to the cicatrix. This method has been only moderately successful in my hands. There are also many criticisms made upon Wolfe's method by Noyes and others. Noyes[3] says that it has become comparatively unsuccessful in his practice, and he has had a great many failures which were so nearly complete that, while he continues to employ it as the first method in some instances, he is by no means enthusiastic about the ultimate issue. Dr. Carmalt (New Haven) in a discussion upon this subject, occurring at the meeting of the ophthalmological society where the operation was considered, states that the ultimate result of a Wolfe transplantation is not to be determined in a few months. Dr. Carmalt, as a general surgeon, has tried the operation in many other parts of the body

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[1] It is even said that the Italian surgeons of four hundred years ago, took flaps from another individual and bound him to the patient.

[2] Transactions of the American Ophthalmological Society, 1885, p. 141.

[3] Transactions of the American Ophthalmological Society, 1893, p. 601.

besides the eyelids, and has found that the process of atrophy or absorption will go on for several months, with most disappointing results. Flaps which, at the completion of the healing, seemed to be perfectly adapted all around, would subsequently shrivel away into almost nothing. This he says has occurred chiefly in the deformities produced by deep burns, where the resulting cicatrix has, by contraction, rendered a limb more or less useless. When he had dissected out the scar, and supplied the gap with fresh and healthy skin, although the first effect might be very promising, at the end of two years, more or less, the result had been so unsatisfactory that the contraction would return to nearly, if not quite, the original condition.

Dr. Lucien Howe, while he admitted that a considerable contraction occurred, confessed that it was new to him that the entire flap had been absorbed. In one case of his, the deformity had not materially increased in two years.

Dr. Reeve, of Toronto, thought the result depended somewhat on the length of time which the lids are kept closed. He believes it important to keep the lids closed for some time. Very good results are obtained in some cases of difficulty with the upper lid, by taking a pedicle-flap from immediately below the lower lid. Dr. Knapp is in the habit of replacing injuries in the upper lid by flaps from below, and Dr. St. John, of Hartford, Conn., reports excellent results from this. Dr. Richard H. Derby[1] reports a remarkable case, when after extensive gangrene of the lids, there was such a subsequent spontaneous restoration of tissue as to almost remove the deformity, or at least to reduce it as much as many successful plastic operations.

It will thus be seen that either in the old method or that of Dieffenbach, a good deal is left to the ingenuity of the individual surgeon, and the result in eyelids, as in plastic surgery everywhere, cannot be certainly predicted. Each case must be worked out by itself. Substantial advance has been made. The Wolfe method is sufficiently successful to warrant its being tried, as Dr. Noyes suggests, in the first instance, in cases where it is not essential to get a flap with a pedicle from a neighboring part, or where the patient will not submit to the terrible distress of having the arm bound to the eye for forty-eight hours.

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[1] *Loc. cit.*, 1884, p. 644.

SKIN-GRAFTING.

By this term is meant the application of very small pieces of the outer layers of healthy skin to the granulating surface. Since the method was proposed in 1869, it has been extensively employed in various parts of the body, even the membrana tympani, in very rare cases, having been replaced by this operation (Ely, Roosa). The part to be covered is to be most carefully cleansed, say with a bichloride or carbolic acid solution, as well as the surface from which the grafts are to be taken. A minute piece of skin from the cleansed surface, which must be entirely free from hairs, is then seized with a pair of fine forceps and snipped off with a pair of fine scissors, curved on the flat. Very small, single-tooth forceps must be used for this purpose. Reverdin used a needle to lift up the epidermis, and shaved the graft off with a thin, sharp scalpel. I have always used forceps and scissors. The piece to be removed is about the size of the head of an ordinary pin. If it is larger, it should be made smaller and cut into two or four pieces, all of which are to be carefully disinfected. The epidermic layer of the skin only should be taken. The cut surface should not bleed, but should show the blood-vessels. The little piece is placed at once on the granulating surface, in the position removed, it being pressed down gently, cut surface downward, with just enough firmness to allow it to adhere, but the granulation should not be allowed to bleed. The grafts are best applied along the edge of the cicatrix, but if it be not too large, they may be arranged in a series of parallel rows across it, or a bridge may be made. After the grafts have been inserted, a piece of thin gutta-percha protective, previously placed in an antiseptic solution for twenty minutes, is laid over the grafts. This is covered by a layer of absorbent cotton, and the whole kept in place by a roller of gauze bandage. This dressing should not be disturbed for about three days, when the coverings, down to the protective, may be taken off to see if there is any considerable amount of pus secreted. If pus has formed and dried, it is to be carefully washed off. This is best done with a syringe or the like, but the surface must not be wiped. If there are evidences of

healing, new dressings may be applied. But if a considerable suppuration has occurred, the gutta-percha is to be removed, and the pus carefully washed off with an antiseptic solution. This process is to be repeated every three days until thorough union has occurred. Grafts from a dead body, that is, six hours after death, have also been used with success.[1] Dr. Brewer,[2] of Norwich, Conn., found that thirty-six hours was the limit of skin vitality. Skin-grafting was intended to be applied chiefly to ulcers, but it has been widened in its applicability to cicatrices on the eyelids.[3]

ENUCLEATION OR EXCISION OF THE EYEBALL.

(Bonnet, Paris, 1841.)

The patient being under the influence of a general anæsthetic, a spring speculum is introduced. The conjunctiva is

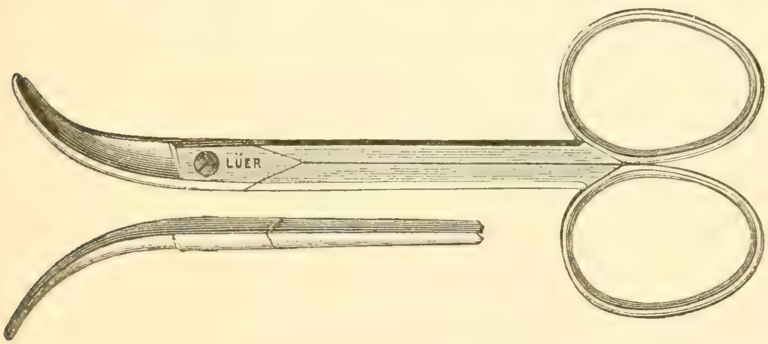

FIG. 122.—ENUCLEATION SCISSORS.

then seized with the forceps exactly as in an operation for convergent strabismus, over the insertion of the internal rectus, that muscle taken up by a hook and separated with scissors curved on the flat.

The conjunctiva is then divided all about the margin of the cornea. The tendons of the remaining muscles are picked up

[1] A fuller account of skin grafting may be found in the "Reference Hand-Book of the Medical Sciences," vol. vi., article by W. H. Carmalt, while in the records of general surgery much may be found to interest the reader of this important subject. See McBurney, Medical Record, Oct. 25th, 1890 ; Reports of the New York Eye and Ear Infirmary, 1892, J. E. Weeks.

[2] Medical Record, vol. xxi., p. 483, May 6th, 1882.

[3] J. H. Girdner, Medical Record, vol. xx., p. 119, July 30th, 1881.

successively by the strabismus hook, and divided close to the sclera. The eyeball is then drawn over to one side by forceps, and strong scissors (with a concavity toward the eyeball) are passed back along its surface to the optic nerve. The blades are then opened, and made to divide the nerve close to the sclerotic. Usually the hemorrhage is slight, and is easily controlled by pressing a sponge for a short time upon the bleeding points. When it has ceased, the lids are closed, and cold cloths applied. Packing the orbit with sponges, ice, and so forth, are usually needless and painful procedures. A compress bandage is useful where there is a tendency to great swelling and ecchymosis of the lids.

If the operation for enucleation of the eyeball, be performed in a hospital, where there are trained nurses and a house surgeon, it will be very rarely necessary to apply a bandage on account of the danger of hemorrhage, but if it be performed under circumstances that prevent there being skilled assistance close at hand, should bleeding occur it will be important to apply a pressure bandage for twelve hours or more. After some considerable comparative experience, had for the purpose of determining this point, I am unable to say that the application of a bandage lessens the ecchymosis and discoloration that generally occur after the operation. Patients are usually able to leave their room in about three days after the operation, and the house in a week. Surgical anæsthesia is to be preferred to local anæsthesia, from cocaine, although if from any reason it be important to dispense with ether, injections of cocaine in the connective tissue of the orbit, will be sufficient to make the pain at least endurable, although such an operation without general anæsthesia must involve great nervous shock to most patients.

As is well known, the laity in some quarters believe that an eye may be wholly removed from the orbit, and then replaced in a sound condition. In one instance in my practice, much to my astonishment, the friend of a patient from whom I had just removed an eyeball, insisted upon my putting it back again, alleging that it had been understood that it was to be replaced, after the foreign body on account of which it had been excised was taken out.

Serious inflammation, erysipelatous in form, may occur after an enucleation of the eyeball, but is very uncommon. I have seen symblepharon result from the neglect of the attendants to thoroughly open the eye, for cleansing purposes, every day after the first twenty-four hours subsequent to the operation.

By this operation, the orbital tissue and muscles are left behind to form a good movable stump for an artificial eye. In certain conditions, as of malignant disease, a considerable piece of the optic nerve is sometimes excised with the eyeball. A suture is sometimes used to close the conjunctiva (Argyll-Robertson, Edinburgh, 1871).

ARTIFICIAL EYES.

Artificial eyes may be worn after the wound has cicatrized and all irritation ceased. It is best to begin to fit them in a

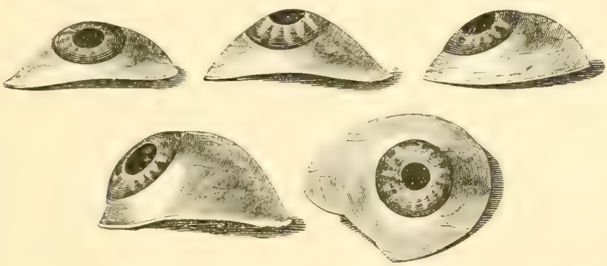

FIG. 123.—ARTIFICIAL EYES.

few days, say seven, after the enucleation, so as to prevent the contraction of the orbital cavity, and to give it a good shape. Patients find their early use better than waiting, since they keep the lids apart. They should be worn at short intervals at first, until the parts become used to the foreign body. If *sympathetic trouble has existed in the other eye*, extra caution should be used lest the artificial eye be worn too continuously. They should not be worn too long without renewal, as they become rough and irritating. They often give rise to severe conjunctivitis of the stump, and possibly to sympathetic irritation of the other eye. Shells are made to be worn over shrunken eyeballs, where no enucleation is performed.

As a general rule, it is better to remove such shrivelled stumps, but if absolutely no irritation is caused by them, enu-

cleation need not be performed, although it is then justifiable if an artificial eye cannot be worn over the stump, or if the patient desires it on account of the appearance.

OPTICO-CILIARY NEUROTOMY

(Von Graefe, Boucheron, Schoeler) is an operation which has been developed since 1867, as a substitute for enucleation, in sympathetic ophthalmia, and in other cases where it is specially desired to save the eyeball. It consists in the division of the optic and ciliary nerves, by a pair of curved scissors passed backward through an opening made in the conjunctiva. It is customary to divide one of the recti muscles to make room for the dissection (although this is not necessary), and its cut ends are reunited by sutures after the nerves have been divided. The operation has not proved to be a good substitute for enucleation. As matters now stand, the consensus of professional opinion is still for enucleation as the only means of preventing sympathetic ophthalmia.

Some operations not described in this chapter, will be found in other parts of the book, in the description of the diseases for which they are performed.

LIGHT FOR OPERATORS.

On dark days, especially frequent in northern climates, the ophthalmic surgeon is often compelled to operate by artificial light. For certain operations, such as needling of membranous cataracts, iridectomies, and cataract extraction, a good light is absolutely essential. When electric light can be obtained, the best possible is had. But one often does well with concentrated gas-light, lamp-light, and very well indeed with the light of a candle in Priestly Smith's lamp, figured in the chapter on Examination.

AFTER-TREATMENT.

This will also be fully discussed later. It is sufficient to remark here, that the after-treatment of operative cases requires special attention and study. After the principal operations upon the eyeball, it is customary to use atropine or eserine, according to indications, to apply compress bandages over both eyes, and to

keep the patient quiet with more or less seclusion from light. When it is desirable to keep the eye closed for several days, the surgeon can judge of its condition, to a certain extent, from the appearance of the lids. If the lids are red, swollen, and œdematous, this may be regarded as an unfavorable indication as to the state of the parts beneath. A purulent discharge is a very bad indication, but there may be, in such cases, considerable blennorrhœa that does not invade even a corneal wound. If severe inflammatory reaction occurs, antiphlogistic treatment by leeches, iced cloths, and so forth, is employed. The operations on the lids, muscles, tear-passages, etc., usually require nothing more than a cold-water dressing, and often not even that.

Cocaine ranks perhaps next to atropine in subduing the pain from iritis and keratitis, traumatic or idiopathic, and is often used in combination with the latter.

ANÆSTHETICS IN OPERATIONS.

For operations for cataract, cocaine is almost universally used. A solution of eight grains to the ounce is sufficiently strong. It is used from fifteen minutes to a half-hour before the operation, dropping it freely on the cornea every three to five minutes. The eye should be kept closed between the time of instillations, lest the epithelium of the cornea be removed by the cocaine. Cases of ulceration of the cornea, resulting from its use, have been reported, but such an occurrence is very rare, and need not be anticipated, if this precaution be observed. The only disadvantage I have ever seen from the use of cocaine on the cornea as a local anæsthetic, is that it sometimes so benumbs the eye that the patients are incapable of moving it up or down, out or in, in response to the directions of the surgeon during an operation, or to shut it well just after. In these cases, it is probable that the anæsthetic has been used for too long a time before the operation is actually begun. In iridectomy for an artificial pupil, or for chronic glaucoma, cocaine is as efficient as in cataract operations. But in acute glaucoma, its use by instillation is not sufficient to still the pain from cutting off the iris. Even when a cocaine solution is dropped directly upon the iris in the anterior chamber, danger to the

eye may result from the violent starting of the patient, when the scissors are being used, in such cases, or when the eyeball is generally inflamed. General anæsthesia or subconjunctival injections of cocaine should be employed. Of late Dr. Frank N. Lewis has employed cocaine compresses with advantage. I have had very little experience with subconjunctival injections of cocaine, but they are recommended by Koller, when instillations are not sufficient.

Koller's methods for producing local anæsthesia are as follows: After having rendered the conjunctiva anæsthetic by instillation of a four-per-cent solution, the speculum is inserted and by means of forceps a fold of the conjunctiva over the tendon to be operated upon is seized. The needle of a hypodermic syringe is thrust through this fold into the subconjunctival tissue as deep as possible, and a few drops of a two-per-cent solution of cocaine are injected. Dr. Koller considers two-thirds of a grain as the utmost limit for adults that can safely be applied as an injection, if the seat of the injection is on the head, while on the limbus a double amount may be allowed. But Koller advises to keep a good way within this limit. Solutions of even one per cent, according to him, are entirely satisfactory, if the solution is well distributed over the field of operation. After the injection of the solution, the speculum is removed, and the eyes closed, so that the artificial œdema of the conjunctiva may be given time to disappear. It will disappear in about five minutes, by a little rubbing. Koller believes that operations on the muscles can be performed in this way, without the slightest pain. Professor Snellen, of Utrecht,[1] also uses subconjunctival injections for cataract operations.

In an operation for strabismus on persons more than ten years of age or thereabouts, I find cocaine an adequate anæsthetic, although it must be admitted that some pain occurs, even with thorough instillations, when the muscle is taken up on the hook. Yet in moderately plucky persons, it is better to cause them to endure this, rather than to subject them to the nausea incident to the use of ether. Young children should be anæsthetized with sulphuric ether, even if the pain may be almost removed by the cocaine instillations. The sight of the

[1] Transactions American Ophthalmological Society, 1892, p. 42.

instruments frightens such patients very much, making them entirely intractable under cocaine, whether instilled or injected under the conjunctiva. One of my first operations for strabismus with cocaine on an adult, who had declined an operation until the use of cocaine was known, was followed by an unpleasant experience, which happily did not last long. The patient was found to be hemiplegic immediately after the operation was finished, but he remained so but a few hours, when he became perfectly well again. He was a man of about twenty-three years of age, of a highly nervous temperament.

Enucleation of an eyeball is to be performed under general anæsthesia, unless under entirely exceptional circumstances. Some surgeons use subconjunctival injections of solutions of cocaine, and injections into the cellular tissue, and are satisfied with the results. Dr. F. M. Wilson, of Bridgeport, writes me as follows: For tarsal tumors that may be removed through the conjunctiva, cocaine is entirely satisfactory. For tumors of the lids which must be removed through the integument, cocaine is not very satisfactory, except when injected into the tumor, or the connective tissue about the growth. If the tumor be large, it might be much better to resort to general anæsthesia. In saturated solution cocaine is of limited value. It is of some service when injected into the canaliculus through the punctum, but this is almost as disagreeable a process as slitting it up. In the vast majority of instances, this operation may be well borne without an anæsthetic.

For the removal of foreign bodies from the cornea, cocaine displays its most marvellous efficiency. Here it is possible to work for some minutes, as the surgeon is sometimes obliged to, in removing a flake of steel or iron from the cornea, where it has become deeply lodged, without causing the patient the slightest pain.

THE ANÆSTHETIC.

This chapter upon operations upon the eye, cannot properly be concluded without expressing the conviction that sulphuric ether, is the best of all anæsthetics for operations upon the eye, requiring general anæsthesia. The grounds upon which this opinion is based are that it is the safest anæsthetic.

In the history of the Manhattan Eye and Ear Hospital, where thousands of operations upon the eye and ear have been performed, under ether, not one life has been lost in consequence of the use of an anæsthetic in an operation upon the eye or the ear. Chloroform, even when used on young subjects, is not without danger. For the administration of ether, I advise a cone made of a towel, lined with paper, larger or smaller according to the age and size of the patient. The ether should be given slowly, and by a person who is instructed to keep his attention fixed upon the patient's respiration, his color, and by one who will have intelligence enough to withdraw the cone, and admit fresh air, as soon as the blood is not properly oxygenized. With skill, it is possible to anæsthetize patients in from two to five minutes. While ether is a more disagreeable anæsthetic than chloroform, the fact of its nearly absolute safety is an argument in favor of its exclusive use, that to me has never been answered. In visiting clinics in France and Germany, I have

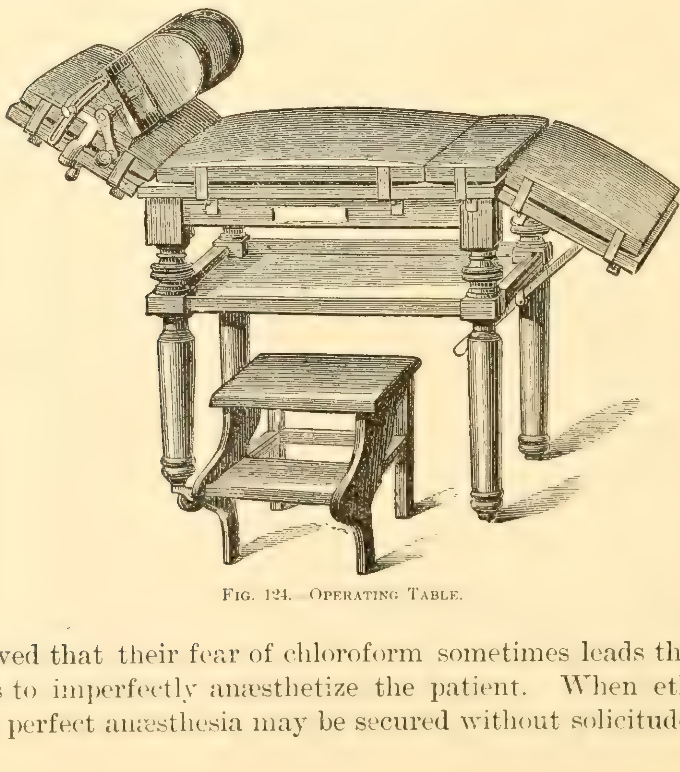

FIG. 124. OPERATING TABLE.

observed that their fear of chloroform sometimes leads the surgeons to imperfectly anæsthetize the patient. When ether is used, perfect anæsthesia may be secured without solicitude. In

two instances or more in my practice, I have been unable to secure anæsthesia without endangering the life of the patient from suffocation. Both of these two subjects were young men. I have heard of a few other cases, as occurring among my colleagues in New York. But they are certainly exceptional.

A whiff of chloroform vapor, inhaled from a small bit of absorbent cotton, saturated with it, held in the nostrils, during the slitting of the canaliculus, forms an exception to my mind, in the use of chloroform and is a proper way of securing local anæsthesia without risk (J. B. Emerson).

OPERATING TABLES.

A plain and strong wooden table, such as is generally used in kitchens, forms an excellent operating table, in private

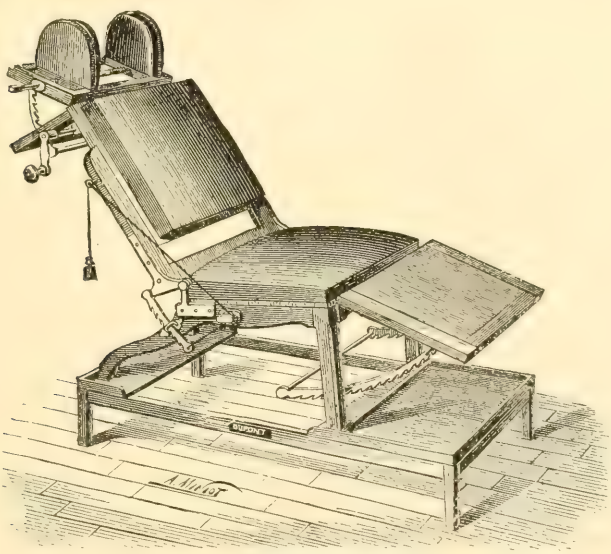

Fig. 125.—Operating Chair.

houses. Beds and lounges are to be carefully avoided, for the obvious reason that they are too low for the convenience of the operator, and for a good light.

For minor operations in a consulting room, what are called sleepy-hollow chairs or so-called steamer chairs, lounging chairs,

with good backs, are very convenient. For hospital work tables on the general pattern shown in the figure are very convenient. Some surgeons dispense with the side supports for the head.

For those who do not find simple chairs sufficient for operations in the consulting room, that here figured (De Wecker's) is also very convenient for many minor operations.

PART III.

DISEASES OF THE EYELIDS, THE LACHRYMAL APPARATUS, THE CONJUNCTIVA EYEBALL, AND ORBIT.

CHAPTER XI.

DISEASES OF THE EYELIDS.

Diseases Symptomatic of Deeper Affections.—Erysipelas.—Blepharitis Ciliaris.—Hordeolum.—Chalazion.—Trichiasis.—Distichiasis.—Entropion.—Ectropion.—Ptosis.—Paralysis of Orbicularis.—Spasm.—Nictitation.—Ecchymosis.—Epicanthus.—Coloboma.—Ephidrosis.—Chromhidrosis.—Xanthelasma.—Blepharospasm.—Wounds of the Eyelids.—Abscess of the Lids.—Syphilitic Diseases of the Eyelids—Epithelioma.

THE diseases of the eyelids are sometimes of an independent origin, but they are often merely symptomatic or dependent upon deeper and more important affections. An examination which finds an affection of the lids, should therefore be very carefully continued, until it is positively determined that they alone are diseased. Disease of the integument of the body may extend to the lids; thus we may have erysipelas, acne, eczema, warts, nævi, syphilitic ulcers, epithelioma, hyperæmia, œdema, cellulitis, and abscesses—in fact, any disease that may attack the skin. A special consideration of such diseases, when they involve the eyelids alone, and not the conjunctiva or eyeball, belongs rather to a treatise upon diseases of the skin than to one on the eye. A few of these affections, however, deserve consideration here, for they may be confined to the eyelids, or they may secondarily involve the eyeball.

ERYSIPELAS.

Facial erysipelas is not only a dangerous disease to the general system, but it may involve the deeper tissues of the eyeball, the retina, and optic nerve, and produce impairment of sight, or even blindness. The extension of the inflammation to the optic nerve and retina, is through the absorbents and blood-vessels of the connective tissue. The tissue of the lids may also slough in the course of a severe attack of erysipelas.

Treatment.—It is not easy to combat a bad case of erysipelas.

It will run its course. But the patient's general condition should be as well sustained as is possible, by the use of nutrients and stimulants. The old lead and opium wash, is as applicable to the eyelids as to any part of the integument. It is serviceable in alleviating the sufferings of the patient. If the connective tissue of the orbit become involved, hot fomentations repeated for fifteen minutes or more every hour will be of value. The eyelids should be kept well lubricated with benzoated lard, vaseline, or the like, in the mean time. It will be only possible to guide the course of the disease, it is probably impossible to arrest it: Its severity and consequent results, will depend entirely upon the patient's strength for resisting the inroads of the poison. The use of antipyretics, such as quinine, antipyrin, and phenacetin, should be carefully avoided. Their effect in reducing the temperature is often illusory, and always unnecessary. They all stop up the emunctories, by which the poison is to be eliminated, if at all; that is, the skin, the kidneys, and the bowels, and some of them dangerously affect the power of the heart. I have seen the temperature in a case of erysipelas of the head reduced from 104° to below normal, in twelve hours, where no antipyretic at all had been given. Such a reduction is not without danger. The surgeon should be ready for it, by having the hot-air bath at hand, and give stimulants by the stomach and hypodermically, and the attendants well warned that such a sudden and great fall of temperature may be expected. Hence everything is to be ready to bring it up again, lest the patient succumb in consequence of the depression.

BLEPHARITIS CILIARIS—BLEPHARITIS MARGINALIS.

Tinea Tarsi (*βλεφαρον*, eyelid).

The characteristics of this disease, are a red line and swelling along the ciliary margin of the lids, while the roots of the eyelashes, and the mouths of the Meibomian follicles, especially the former, are encrusted with dried purulent and catarrhal secretion. The cilia themselves, are often matted together by the secretion.

Blepharitis ciliaris is essentially a disease of the roots of the hair follicles, and the Meibomian glands. As it advances it also

involves the connective tissue. The edge of the lid is at first hyperæmic, but in time atrophy occurs, and it becomes smooth and glistening. The secretions of the follicles and glands, if not very often removed, thicken and harden about the lashes, and produce crusts. The hairs fall out, little pustules having formed about their roots. The new growth of hair is apt to be pale, thin, stunted, and misdirected. When the disease has so progressed, the edge of the lid sometimes becomes hypertrophied and callous. This disease or condition was formerly known as tylosis (τύλη, callous). The lid may also become everted. The hair follicles may be so completely destroyed, that the hair will cease to grow altogether—madarosis (μαδαρός, bald). This affection occurs in children and in adults, in varying degrees of severity. It seems especially apt to attack blondes. When occurring in the very young, it is usually very tractable to simple treatment. It was the idea of some of the older authors that it was essentially a disease of strumous origin. It is probable that it has no such specific origin, but that it is frequently the result of anæmia, induced by bad general nutrition. It is commonest among the infants and children of the poor, such as the tenement-house class in New York, but it occurs among all poorly nourished people, as it does in half-starved domestic animals.

There are two classes of cases. One is a simple form, easy of cure, the result of a catarrhal conjunctivitis, in which ordinary local cleanliness has been neglected. There is a second, where either from grave constitutional conditions or uncorrected errors of refraction, deep-seated disease of the hair follicles has occurred. In 1876,[1] I showed by a series of cases, that blepharitis ciliaris was very often associated with an error of refraction, usually astigmatism, and that the most efficient local measures would only partially succeed in such cases, unless the strain of the accommodation was relieved by a correction of the refractive error. Although this opinion was stoutly resisted on its promulgation, by some authorities, it has since been abundantly verified by Risley (Philadelphia), Noyes, and many others. Strain, and consequent fatigue of the accommodation, is by no means confined to school children and adults. Even

[1] International Congress of Ophthalmology, New York, 1876. Also Transactions American Ophthalmological Society, 1878.

very young children, in their plays, often call into action a great deal of accommodative power. Children who have a considerable degree of astigmatism, or who are very hypermetropic, will especially suffer from such a strain. Hypermetropia, if associated with blepharitis, unless it be of a high degree or connected with astigmatism, cannot be said to be the exciting cause of the blepharitis, because the greater proportion of the civilized races at least, are hyperopic. Opacities of the cornea, which are situated over the pupil, and consequently impair the sight, and cause a permanent accommodation strain, are a fruitful source of blepharitis ciliaris.

Treatment.—The first essential is to secure and maintain perfect cleanliness of the hair-follicles, Meibomian glands, and other parts making up the edge of the lids. The use of simple water is not sufficient for this. An alkaline solution added to it is necessary to dissolve the crusts which accumulate so rapidly about the roots of the lashes. Bicarbonate of soda, ʒi. ad ℥iv. of rosewater, is a very good application. It should be thoroughly used by means of absorbent cotton, bits of old linen, or the like. In severe cases, it will be necessary to use this application three or four times a day, but generally treatment in the morning and evening will be found sufficient. The patient's attendant, or the patient himself, should be taught to do this. After all the crusts are thoroughly removed, an ointment of yellow or red oxide of mercury, one to two grains to the drachm of benzoated lard, simple cerate, or vaseline is usually the best application. In some cases the surgeon will do well to apply a ten-grain solution of nitrate of silver to the roots of the hair-follicles. When this is done, the nitrate of silver may be neutralized with vaseline, or the like. This is better than using salt and water for this purpose.

In chronic cases occurring in adults, or in children old enough to read, the refraction should be carefully examined. If astigmatism, hypermetropia of a high degree, or myopia be found, it should be corrected, or a cure will be more difficult. In severe cases, it will be well to apply a four-grain solution of the sulphate of atropia or a one-grain solution of scopolamine, and let up the strain on the accommodation for ten days or two weeks. This will greatly facilitate the cure,

and at the same time demonstrate about how much the strain upon the accommodation, influences the course of the disease. In cases of blepharitis ciliaris caused by opacities of the cornea, it is generally impossible to do any more than to mitigate the affection by constant care of the eyes, in the manner that has been indicated. In many cases, especially in very light blondes, perpetual local applications are necessary to permanently remove the red line along the lids, so characteristic of a mild form of this disease. There are, however, many cases that are entirely cured. One of the first cases that called my attention to the bad effects of errors of refraction and strain of accommodation, upon the edges of the lids, and which led me to investigate the subject, was one of mixed astigmatism, in a book-keeper of twenty-five years of age, whose case had been treated for four years under skilful hands without relief. In two months after the use of correcting glasses and very simple local treatment, he was well. Many cases followed this one, until the importance of examining the refraction was seen. I was in the habit, while investigating this subject, of looking about my class at the University Medical College, for young men with marked cases of blepharitis ciliaris, and I almost always found the inflammation of the lids associated with refractive anomalies that had not been corrected.

It is an interesting observation, that patients who suffer markedly from blepharitis do not usually complain of watering of the eyes, headache, and the other symptoms of what is called asthenopia. The evidences of strained accommodation are chiefly found in the condition of the lids. When patients suffering from asthenopia are interrogated, it is found that one of the first complaints is of a heat in the edges of the lids, a feeling as if there were a band about them. The congestion or hyperæmia in the hair follicles or Meibomian glands, with the consequent sensation of heat, is the beginning of the asthenopic symptoms. Why, in some cases, this hyperæmia goes on to be true inflammation, and in others, no matter how long the asthenopia exists, never gets beyond the stage of hyperæmia, is an interesting question which I am unable to answer.

BLEPHARITIS TARSALIS—HORDEOLUM.

(*Hordeolum*, stye.)

A stye is characterized by a localized redness and swelling, which can generally be traced to a Meibomian follicle. The swelling is so circumscribed that the skin can be freely moved about it.

A stye is a boil affecting the connective tissue, and a Meibomian gland, at the edge of the lid. Styes are apt to appear in succession. Certain subjects are especially liable to them, if the general system becomes at all run down from general causes. Like boils in other parts of the body, they give evidence of impaired nutrition. They cause considerable pain, and swelling and deformity of the lid. The pain is sometimes excessive, as if the patient were suffering from periostitis of the edge of the orbit, or the malar bone. While styes more frequently occur in those persons who have a marked refractive error, they also arise where the accommodation is overstrained, in persons with no marked refractive anomaly. For example, while preparing these pages for the press, I have seen a strong, large man of forty-five, with an out-door occupation, suffering from a large stye. On close examination to learn, if possible, the origin of his trouble, the only clew I could find to the etiology was the fact that although he was well on in presbyopia, he wore no glasses for the little reading he may have done, as he was an illiterate man, nor for looking at fine objects. This was a slender foundation on which to build a theory, and as he was in vigorous health, I was obliged to say I could trace no cause for his stye, in any history or symptoms I could get from him.

Those who are satisfied with the statement that morbid germs cause all diseases, will no doubt say that hordeolum results from local infection with a hordeolum bacillus. But a healthy eyelid, or a healthy Meibomian follicle, will probably resist an attack from such a source. The problem as to the preparation of the soil for the morbid germ, remains unsolved in many such cases, probably from our want of information as to the local or general irritants which have preceded the inflammation.

Treatment.—Hot fomentations or small poultices should be

used, until pus has formed, when the tumor should be fully opened by an incision parallel to the edge of the lid. Styes are sometimes aborted, if touched with a solution of nitrate of silver, gr. xx.–xl. to the ounce, when they first appear, or if an ointment of red oxide of mercury, one grain to a drachm of benzoated lard or the like, be rubbed into them. I may here add to what has been said upon the subject of the connection of blepharitis ciliaris with errors of refraction, that it applies also to styes, tarsal tumors, chalazia, or to any affection of the lids. The refraction should always be carefully examined in cases of styes and so forth. Their recurrence may often be prevented by a correction of the refractive error.

CHALAZION.

(*χαλαζα*, hail.)

This is also known as tarsal tumor or tarsal cyst. It is the so-called *retention tumor* of the Germans. It is formed by an inflammatory obstruction of the mouth of a Meibomian gland, which expands laterally and produces the tumors, which sometimes grow to the size of a hazelnut. Usually they are much smaller. Two or more may grow in the same lid. They appear either in the upper or lowerlid, and are usually quite disfiguring. Masses of such growth often appear and disappear, without treatment, but this cannot be certainly counted upon, in an individual case. Sometimes this removal is by absorption, but in rare cases suppuration occurs, and finally the abscess ruptures, occasioning considerable disfigurement and inconvenience for the time.

Treatment.—When a tumor has existed for some weeks, and is large enough to be a deformity, it is better to remove it by incision. If it can be reached through the conjunctiva, instillation of a four-grain solution of hydrochlorate of cocaine will prevent any pain from the first incision. If the patient be one who cannot bear even a little pain, it is better to wait after the first incision, until the tissues beneath are cocainized, when the operation can be finished. Sometimes general anæsthesia is necessary. Various instruments have been invented and modified with which to grasp the tumor while performing this operation.

Many practitioners find advantage in their use, but I employ a simple spatula, or, in some cases, the thumb and finger. The advantage of the ring forceps is that they restrain the hemorrhage during the operation. But that advantage is more than compensated for, in my opinion, in that the tissues are so compressed during the operation, as to render ecchymosis more likely, so that the patient is disfigured for some days after. After making a free incision in the conjunctiva or integument,

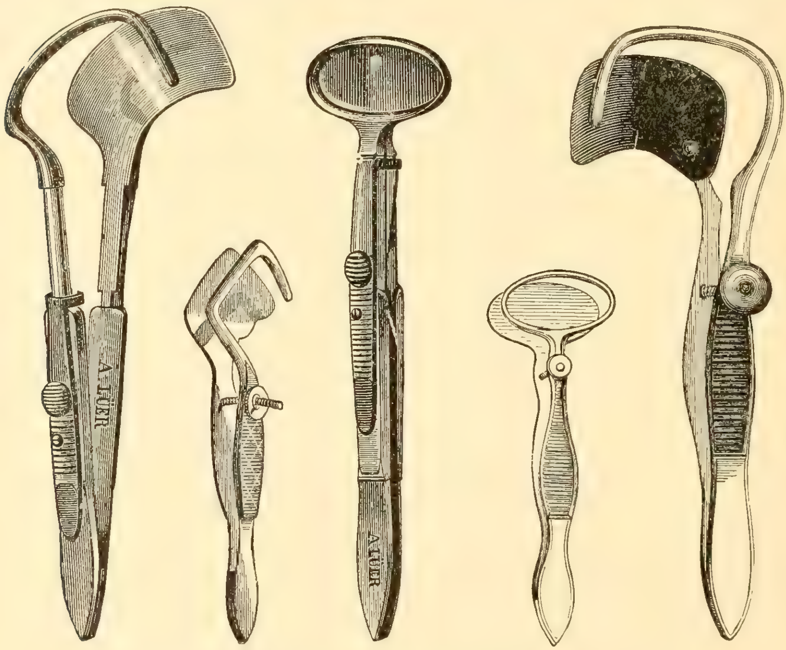

FIG. 126.—RING FORCEPS. For encircling chalazia before removal.

a choice of an internal or external opening being made, according to the stretching of either part, cocaine is reapplied. This first incision should be deep enough to come at once upon the walls of the tumor, which may be dissected out or cut into. If the latter, after the contents of the cyst are thoroughly evacuated, the cyst-wall or lining should be thoroughly scraped with a small spoon, so that the likelihood of a return of the tumor is lessened. If not patiently and thoroughly removed, it may return or never wholly disappear.

It is not well, simple as the operation for removal of a cha-

lazion is, to attempt it without an assistant. A simple incision will but usually be sufficient, but considerable dissection may be required, which the surgeon cannot properly carry out unaided. If the tumor be removed through the integument, a suture or two will be needed to close the wound. The proper dressing

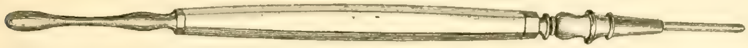

FIG. 127.—SPOON FOR CHALAZIA.

will be a flannel bandage, if the patient is to be exposed to the cold or wind afterward, and the incision is through the integument. In case the tumor is small, and the patient very much disinclined to the removal by cutting, massage, a daily application of the tincture of iodine, or the Faradic current of electricity may be tried.

PHTHIRIASIS.

(φθειρ, a louse.)

This condition may be mistaken for blepharitis ciliaris. It is an affection of the margin of the lid, caused by the presence of the so-called crab-lice, *pediculi pubis*, upon the eyelashes. The patient of the lower walks of life is not usually aware of their presence. They cause great itching, which induces the attempts at relief, leading to great congestion. The eggs of the animal may be detected on the cilia by close examination, and the parasites themselves may also be discovered. The proper treatment is by means of mercurial ointment. This should be well rubbed into the margins of the lids, when it will dislodge the parasites, so that they are easily seen and removed with forceps.

EPITHELIOMATA.

Epitheliomatous tumors sometimes originate in the eyelids. They should be thoroughly removed with the knife, as soon as detected. Warts upon the eyelids often form the starting-point of epitheliomatous growths upon the eyelids. They are to be looked upon with great suspicion when they thus appear. They are readily removed by a sliding flap operation. If they are attacked at an early stage and the removal is thorough, the prognosis is good.

I have watched such cases for ten years or more, and have seen no return. When they have become large and have made a large ulcerative surface, it is not only difficult to secure a thorough removal without great deformity, but the return of the growth is probable.

TELANGIECTASIS AND ANGIOMATOUS GROWTHS.

(*τηλε*, far; *ἀγγειον*, a blood-vessel; *ἐκτασις*, dilation; *ἀγγειον*, a blood-vessel.)

These growths may occur on the eyelids. They are congenital, and may be removed at an early period, by the knife. This means is better than the use of the actual or galvano-cautery, because it is less likely to leave a scar.

DISTICHIASIS AND TRICHIASIS.

(*διστιχια*, a double row; *τριχιαω*, to show hairs.)

The first of these conditions means a double row of lashes turning inward upon the eyeball. Trichiasis is a turning in of the lashes, without their being a double row. Both of these conditions are often associated together. The double row is some-

FIG. 128.—OPERATIONS FOR DISTICHIASIS (STELLWAG).

times only apparent, and is caused by stretching of the outer lip of the lid (Stellwag[1]). These conditions are actually parts of the condition called entropion. Yet the invasion of the cilia is almost always a consequence of trachoma, that is to say, a result of the atrophy of the connective tissue, and distortion

[1] "Text-Book," English translation, Roosa, Hackley, and Bull, New York, 1873, p. 462.

of the tarsal cartilage caused by this disease. In old people, entropion is often a spasmodic affection, resulting from the lax condition of the integument with an absence of fat and sebaceous follicles. It is very apt to occur in such subjects, after the bandaging of the eyes consequent upon an operation for cataract.

Treatment.—The treatment of distichiasis and trichiasis is chiefly by operations, which have been described in Chapter X. Spasmodic entropion may often be cured by the application of adhesive plaster to keep the lid well drawn down. Ectropion has also been described sufficiently in the chapter devoted to operations.

PTOSIS (πτωσις, falling) is a drooping of the upper lid, either partial or complete. It is caused by injury of the levator muscle, swelling and increased weight of the lid from inflammation, or by paralysis of the third nerve. It is sometimes seen in old people, when it is caused by great relaxation of tissues. It may be also congenital. Ptosis is thoroughly considered in the chapter upon paralysis of the ocular muscles.

PARALYSIS OF THE ORBICULARIS MUSCLE, is a result of paralysis of the portio dura of seventh nerve. The lids cannot be completely closed, and the patient thus has a peculiar staring appearance called lagophthalmos (λαγως, a hare, and ὀφθαλμος, eye). The lower lid falls away from the globe, so that tears run over, and the eye suffers excessively from a constant exposure to external irritants, winds, dust, smoke, and the like.

EPHIDROSIS, is an excessive secretion of the sweat glands of the lids. It causes itching and biting sensations and irritation and inflammation of the skin and of the conjunctiva. It is difficult to cure.

CHROMHIDROSIS, is a dark blue or black discoloration of the skin of the lids, appearing suddenly, and capable of being washed off with glycerin and rosewater. It is seen chiefly in hysterical females, and supposed, by some authors, to be always due to simulation.

XANTHELASMA, XANTHOMA (ξανθος, yellow), or VITILIGOIDEA (*vitium*, a defect) appears as peculiar yellow patches, usually situated on the skin of the eyelids, and most often the upper lid, near the inner canthus. Sometimes the patch is raised a little, sometimes not. The disease is most common in females, and

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in those of middle age. Dissection shows that the connective-tissue cells of the parts are filled with fat. By some there is thought to be a connection between xanthoma and liver trouble. Excision of the patches is proper treatment.

Blepharospasm.—This is a symptom rather than a disease, although it may become a chronic one. It is essentially a spasmodic contraction of the orbicularis, so that the lids are tightly closed against the globe. When this is a constant condition, it is a result of photophobia, which is an accompaniment of the various forms of phlyctenular disease, which are fully treated in another chapter. Blepharospasm is a reflex irritation from the fifth nerve. It occurs also in neuralgia of all the branches of this nerve, from the presence of foreign bodies, errors of refraction, and so forth. It may be a result of spinal disease.

Treatment.—This should be directed toward a removal of the cause. The symptom is often alleviated by immersion of the face in cold water, frequently repeated. Canthotomy is often performed with benefit on account of blepharospasm. In pure neuralgia of the fifth pair division of the affected nerve is sometimes practised.

Blepharospasm sometimes occurs in persons in adult life, and is marked by a frequent rapid and violent closure of the lids. Every few seconds, especially when mentally excited, the lids are firmly pressed together. There is then an interval of quiet to the eyes. This condition is not susceptible of relief by ordinary methods. The subjects of it regard it as a habit, and seldom apply for relief.

Nictitation.—Associated with blepharospasm is a constant or very frequent winking, nictitation, which is an evidence of nervous exhaustion from various causes. This occurs sometimes as a twitching of the muscle of the upper or lower lid, a contraction of the small muscular fibres of the orbicularis. This is sometimes invisible, except on close examination, but it is always extremely troublesome to the patient. It is a positive symptom of nervous exhaustion. It sometimes extends to the muscles of the face. In rare instances it becomes a constant condition.

Treatment.—The use of alcoholic stimulants at meals, such as champagne, the administration of tonics, especially strychnia, complete mental and physical rest will almost invariably

break up this troublesome symptom in persons of usually good health.

ECCHYMOSIS OF THE LIDS.—This is an effusion of blood into the cellular tissue, consequent on blows or other injuries. It is known in popular language, as a black eye. Cold applications, a compress and bandage are useful applications to promote absorption of the blood and coloring matter. In large cities, there are men who make a business of covering up this deformity, so apt to occur as a result of pugilism, by skilfully painting the parts. A poultice of an oyster, is a favorite application with many of the victims to their own habits, but it is a dangerous remedy because it may break down the tissues and produce a very obstinate keratitis.

WOUNDS OF THE EYELIDS.

These should be very closely examined when they first come under observation, to see if the wound of the lid is the only lesion. The globe of the eye is very often wounded, and sometimes a foreign body has entered it, when on superficial examination only the eyelid seems wounded. Wounds of the eyelids, if recent and properly united, heal promptly, and very often most serious ones leave little deformity, there being ample tissue to make up for loss. The edges of the lids should be brought together by fine black silk sutures, and a compress and bandage applied. If the parts are very hot and uncomfortable, iced cloths should be used. It is necessary to freshen the edges of wounds more than twenty-four hours old, in order to secure union by first intention. Wounds of the upper eyelids are sometimes so deep and extensive as to involve the levator palpebræ. Prompt treatment of the parts with subsequent use of the Faradic current, sometimes restores the functions of the nerves.

BURNS OF THE EYELIDS.—These should be treated like burns of other parts of the general integument. Collodion is an excellent application in the first stages and also gum-arabic. If only the epidermis be involved, very little harm will be done, but if the true skin be invaded, deformity from contraction is likely to occur, which will be more or less corrected by plastic operations.

Epicanthus (ἐπί, and κανθός, upon the corner of the eye).—This is a congenital malformation, depending upon a want of development of the bridge of the nose, so that a crescentic fold of the skin overlaps the inner canthus more or less. The cutting out of an oval piece of the integument of the bridge of the nose, and closing it by suture, will improve but not entirely relieve the condition of things.

Coloboma (κολόβωμα, mutilation).—Congenital fissure of the lid. This is sometimes associated with coloboma of the iris and choroid. It is analogous to harelip, cleft palate, and so forth. A simple plastic operation is often sufficient to relieve the deformity.

Abscess of the Lids.—As a result of injury or spontaneously, abscess of the lid may occur. Although abscesses may cause great swelling and deformity of the lid, while in progress, they usually subside rapidly after evacuation of the pus, and leave no scar.

Syphilitic Eruptions and Ulcers of the Eyelid.—The careful observer will be on the lookout for syphilitic ulcers on the eyelid. Chancres have been found there. The authorities on syphilis regard syphilitic affections of the lids as very rare. The ophthalmic surgeon very seldom sees them. The eruptions are more properly discussed in the treatises on diseases of the skin. A chancre of the lid will not be mistaken. The true syphilitic ulcer, however, may be mistaken for epithelioma. The administration of iodide of potassium will soon clear up doubtful cases, for it has a magical effect upon a syphilitic lesion of this kind.

I have seen a few cases of extensive ulceration of the lids, supposed to be due to malignant diseases, entirely cured by the faithful administration of this drug, and the diagnosis of secondary syphilis made as the result of the treatment.

CHAPTER XII.

DISEASES OF THE LACHRYMAL APPARATUS.

Diseases of the Lachrymal Glands, very Rare.—Lachrymal Catarrh.—Dacryocystitis.—Causes.—Treatment.—Bowman's Method.—Strictures in the Nasal Duct.—The Use of a Knife in the Nasal Duct.—Gradual Dilatation.—Blennorrhœa.—Abscess.—Fistula.—Destruction of the Sac.—Cilia in the Punctum.

DISEASES of the lachrymal glands are of very rare occurrence. There may, however, be abscesses of the gland, and cysts, dacryocystitis (*δακρυον*, tear, and *ὀψ*, eye). This latter disease is generally due to closure of the excretory ducts, and distention from retained secretion. Malignant tumor, sarcoma, may form in the gland, when extirpation of the growth must be performed. The abscesses are to be opened, and cysts removed.

Disease of the puncta, the canaliculi, the lachrymal sac, and the nasal duct, of each or of all, are very common affections. Of 9,937 cases occurring in my private practice, 508 were of this class. In the Manhattan Eye and Ear Hospital, of 9,720 cases treated in 1891 and 1892, 159 were cases of disease of the tear passages.

LACHRYMAL CATARRH.

LACHRYMAL CATARRH is characterized by an increased secretion in the canaliculus, the lachrymal sac, or nasal duct. This causes an overflow of tears. In mild forms it is chiefly noticeable out of doors, especially on windy or cold days. In severe cases it is constant. The patient is compelled to wipe the eyes every moment, and continuous occupation on objects near at hand is almost impossible. Generally, however, the catarrh has advanced to a stage of blennorrhœa, before this occurs. There is usually some swelling in the lachrymal sac, as a result of this catarrhal inflammation. As the disease advances, there may be a positive stricture either in the canaliculus, the sac, or duct, and

rarely the punctum itself is stopped up, so that the tears scarcely pass through at all. This state of things soon leads to blennorrhœa, and possibly to abscess.

Causes.—A few cases of a mild form, where the symptoms are most manifest on use of the eyes, depend upon uncorrected errors of refraction, and the trouble is really a form of asthenopia. In a large proportion of cases, it is a purely catarrhal affection, and produced by the same causes that bring on catarrh in other parts of the naso-pharyngeal tract, colds in the head, and catarrhal conjunctivitis.

Syphilis plays an important part in producing catarrh of the lachrymal passages. It is not an uncommon symptom of both the acquired and congenital form. In this disease it is apt to advance, unless met by timely, anti-syphilitic treatment, to caries and necrosis of the lachrymal bones, while in the simple local variety, it very seldom becomes such a serious disease. It is much more apt to remain as a (watery eye) *stillicidium lachrymarum*, dripping of tears. The older writers make a separate classification under this head, but as the so-called *stillicidium* is a mere symptom, this is manifestly incorrect.

Treatment.—The treatment by Bowman's gradual method of dilatation, still remains the best that has been suggested. There are many objections to this method, urged by those who look for speedy and rapid methods of cure in chronic disease. That such are not usually to be expected, is in the very nature of things. The treatment requires the personal attendance of the patient upon the surgeon, at first every day, and a little later for two or three times a week. In a few instances, patients or their attendants may be taught to introduce the probe themselves into the nasal duct. In a few others, the relief is immediate after a very few probings, so that the treatment is not tedious. It must be confessed, however, that the treatment, if successful, generally requires from six to twelve weeks' attendance, and in some instances even longer. In some cases that are not severe, the treatment fails, but the results are better than is usually thought.

Bowman's Operation: Dilatation of the Canaliculus.—I think it often better to dilate the canaliculus before dividing it. The dilatation is not a painful procedure. It accustoms the

patient to the use of instruments, and favors the proper performance of the second and painful steps. The patient should be seated in a convenient chair, such as has been described in Chapter X., and which is in many private houses, or can be readily secured. If more convenient the patient may lie down. The surgeon, standing behind, depresses the lower lid, and exposes the punctum thoroughly. Sometimes it is so small or there is so much spasm of the muscles, so much timidity of the patient, that it is difficult to enter it. An assistant, for which purpose any good servant or office attendant may be brought in, is very useful, although usually not indispensable. After the punctum is entered, the canaliculus being kept well on the stretch, it is thoroughly dilated, *well into the lachrymal sac.* Then the probe is taken, and the canaliculus thoroughly divided, with the knife, *also well into the sac.* The latter part of this proceeding is sometimes difficult on account of adhesions produced by inflammatory action or because the parts are not kept well stretched, and a fold of mucous membrane gets in the way. A little experience will soon enable the operator to know whether or not he has completely succeeded. If he has not, the next and final step, the introduction of the probe, will be difficult and sometimes impossible, without making a false passage. A probe is taken and introduced well into the sac, and then turned into the nasal duct, having of course first been bent so as to adapt itself to the face. These probes are usually and better made of silver, but not of too fine a quality. It is difficult to say what size one should begin with, usually with the Number 4. In rare cases Number 6 or even 8 may be introduced, at the first sitting. In some cases, it is necessary to use even as small

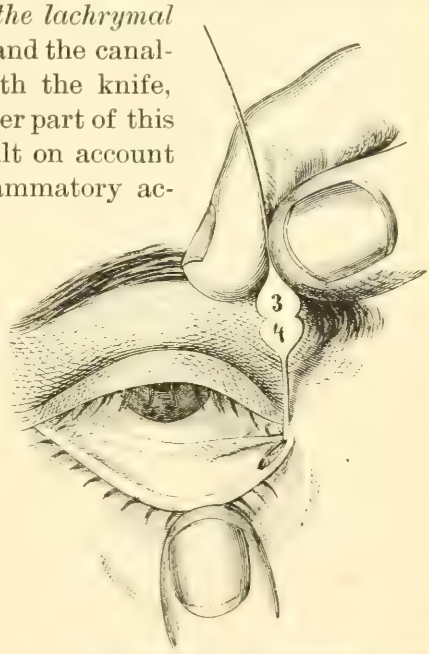

FIG. 120.—PROBING THE NASAL DUCT. After Stellwag.

a probe as Number one. This is readily determined, by the obstruction met with in dilating the passages with the probe for the canaliculus. If the canaliculus probe, goes easily into the sac, quite a large probe may be used, at once. In my practice, I rarely have occasion to use a larger probe than Number 8, especially in true catarrh, but when blennorrhœa or abscess has occurred, and the passages have become much dilated, or death of the bone has occurred, it may be necessary to use even Number 20. Preliminary to the probing, in cases where the catarrh is considerable, and in all cases of blennorrhœa, it is well to syringe the lachrymal passages with a solution of common salt and water, and afterward in some cases there is advantage in syringing the parts with an astringent solution: nitrate of silver, one to five grains to the ounce; sulphate of zinc, gr. ij. ad ℥i., or the like. This is not usually necessary in mild catarrhal cases. De Wecker devised a hollow probe for syringing the parts. It is sometimes very useful (see Chapter X.). Some authorities (Stilling) introduce a knife into the nasal duct and divide the strictures. This is a method much inferior, to my mind, to gradual dilation with a blunt probe, and after a few trials, and after seeing much use of the method in the hands of others, I declined to adopt it, and continued to adhere to Bowman's method. Again, some authorities speak well of leaving a lead or silver probe in the nasal duct for some days. This method of treatment was obviously adopted for the laudable purpose of lessening the frequency of the patient's visits to the surgeon, as a short cut to the end in view. Like many other short cuts, it is not really the shortest way. Considerable reaction may follow this method of treatment. The patient at least finds it very trying to wear the probe, and the suppuration may be annoying. After faithfully trying this method also, I came back again to gradual dilatation.

Just how much force to use in dilating a nasal duct, it is difficult to say. One must not be too delicate here, in manipulation. The parts concerned are not at all so sensitive to overdistention, as is the male urethra, for example. Neither need one dread a false passage, much as it is to be avoided, for its dangers are not so great, from the very nature of the anatomy of the parts, as a false passage in the male urethra. A little

nasal hemorrhage after the operation, or even a considerable, is not at all a serious matter. Considerable ecchymosis may follow an operation, when it is difficult to get into the sac or the nasal duct. Cases have been known, where orbital cellulitis has occurred after a lachrymal operation and injection with a solution of peroxide of hydrogen. In one instance the cellulitis was so severe as to finally cause atrophy of the optic nerve, probably through pressure. These cases are, however, inadequately reported, and it is difficult to say just what factors were potent in producing so severe an inflammation.

Sir William Wilde once sent me word, by a very intelligent patient, whom I was treating for a bad case of lachrymal catarrh, that I was dealing too gently with the case, that I should use a large probe and hurt the patient more. I took his advice, and my patient, who had a bad case of simple catarrh, recovered. Of late, since so much discriminating attention has been given by scientific surgeons to the surgery of the nose and to its diseases, more attempts have been made to cure lachrymal catarrh, simply by removing nasal obstruction and combating nasal inflammation. I am doubtful if lachrymal catarrh be not too local an affair to be cured by treating the mucous lining of the nasal cavity, or of the turbinated bones, but certain it is that the thorough examination of the nose in all obstinate cases, or in aggravated cases, should never be neglected, and treatment adopted if necessary. I think, however, that in true catarrhal cases of lachrymal disease, the causes, such as catarrhal conjunctivitis, have usually run their course, leaving only the lachrymal catarrh behind. This is, however, not the case always, especially in blennorrhœa or abscess.

LACHRYMAL BLENNORRHŒA.

This is but a step forward from lachrymal catarrh. In this form the lachrymal sac becomes distended, and mucus mingled with pus, may be readily pressed out of the punctum by the fingers of the surgeon. Where the condition has existed for some time, the patient is in the habit of pressing the muco-pus out of the sac, either into the nose or upward through the punctum. It will sometimes find its way, into the

upper punctum and canaliculus instead of the lower. Blennorrhœa of the sac is a condition imperatively requiring relief, yet bad as the condition is, some patients, and not necessarily unintelligent persons, will go on pressing out the muco-pus for years, rather than submit to a dreaded surgical operation. In such cases the lachrymal sac becomes greatly distended, and relief not being afforded, it swells more and more, until finally an opening is made by nature and a lachrymal fistula is created.

Treatment.—Although the conditions are so much worse and the urgency greater in blennorrhœa, the treatment should be exactly the same as that advised for lachrymal catarrh. Relief is very apt to be immediate after the opening of the sac. The presence of a fistula, does not change the necessity for making the opening through the punctum and canaliculus. The operation is much more difficult on account of the distortion of the lids, and displacement of the punctum. Sometimes the patient must be put under the influence of general anæsthesia, in order to properly treat the case.

LACHRYMAL ABSCESS.

This condition, which has been alluded to in the preceding discussion, is rarely, if ever, a spontaneous one. It may occur in the course of any case of lachrymal catarrh. It is a severe disease; there is great swelling of the lachrymal sac and lids, with redness, tension, while the patient experiences much pain; the general temperature of the body is usually elevated. So great is the swelling, so intense the redness of the lids, which sometimes extends to the face, that it is not an extremely unusual thing for a practitioner, who has not had much experience with lachrymal disease, to mistake lachrymal abscess for facial erysipelas, until the occurrence of a fistula, the escape of pus, and the subsidence of the inflammation change the diagnosis. In any suspicious redness and swelling of this kind, it is important to make inquiries as to the existence of a *weeping eye*, for some time preceding the origin of the swelling. If it be found that this has been the case, a close examination will soon conclusively show that the origin of the erysipelatous-looking inflammation is actually in the tear passages.

Treatment.—If the patient be seen before a considerable abscess has occurred, it may be sufficient to open the canaliculus and probe the nasal duct. This should be followed by the frequent use once an hour, for fifteen to twenty minutes, of fomentations of hot water, or even a flaxseed poultice. If the latter be used it should only be continued for a few hours, and then care be taken that it is applied only on the sac, lest too great relaxation of the tissues of the conjunctiva occur. If it be evident that considerable pus is distending the sac, besides the opening of the sac through the punctum and canaliculus, the abscess should be opened by a free incision, made preferably with a Beer's knife, or scalpel well down in the brawny tissue to the bone. No fear of a scar need be entertained, even in the case of a beautiful woman. There is much redundant tissue here. I have never known a scar to occur after such an operation, and I have performed many. For this reason I do not perform the more difficult operation of opening the sac from behind. This is merely to attempt to avoid that which does not occur.

Lachrymal blennorrhœa and lachrymal abscess, are converted into simple cases of lachrymal catarrh, after the subsidence of the acute symptoms, and are to be treated in the manner that has been detailed in discussing that subject.

Lachrymal fistula has been sufficiently alluded to in the foregoing remarks, to make it only necessary to say, that where such a condition has occurred it is to be treated just as lachrymal catarrh, by opening the sac, through the canaliculus, and dilating the duct with Bowman's probes.

CARIES OF THE LACHRYMAL BONES—DESTRUCTION OF THE SAC.

In some totally neglected cases of lachrymal disease, where the various stages of catarrh, blennorrhœa, abscess, and fistula have been passed through, and besides caries may have occurred, it may be necessary to destroy the sac. These cases occur chiefly in very poorly nourished, perhaps syphilitic subjects. Necrosis of the bone having occurred, even moderate relief by probing is not possible. It is better in such cases to proceed to destruction of the sac, which, while it cannot afford

a complete relief from the watery eye, does very much to improve the condition of the patient. The sac is destroyed in the following manner. The patient being under the influence of ether, the sac is freely opened and exposed, and its lining destroyed by the actual cautery, or fuming nitric acid, or solid nitrate of silver. When the acid is used, the lips of the wound are held wide apart, and great care taken to prevent the fumes of the acid from reaching the cornea. Noyes considers that the relief afforded by this operation, is due to the fact that there is no longer an irritation in the sac to produce a superabundant flow of tears.[1] In rare cases, when the nasal duct is entirely stopped up it is necessary to drill through the bone. This must be done under ether. Subjects with lachrymal disease requiring obliteration of the sac or drilling of the duct are often, if not usually, affected with congenital syphilis. This disease, either acquired or congenital, must be carefully searched for in many forms of lachrymal disease. Local treatment by itself will be of no avail without the constitutional remedies, in cases where syphilis is one of the causes.

Dr. Osborne, of Hamilton, Canada, calls attention to the well-known fact, but one not always fully recognized, that there may be what he terms *pathological weeping*, when all the lachrymal passages are in excellent condition. I have very lately seen a marked case of this kind, in a physician of about fifty years of age. His eyes were constantly bathed in tears, and yet the conjunctiva and lachrymal passages gave no evidence of disease. There was no disease of the fundus oculi. Under the use of a lotion of acetico-tartrate of alumen, one grain to the ounce, in about a month the watering was greatly relieved. Here the conjunctiva was probably the source of the trouble, although it gave no evidence of it by redness or swelling. Dr. Osborne recommends the injection of the punctum and nasal duct with a blunted hypodermic syringe to determine whether or not the nasal ducts be occluded before operating in these cases of general suffusion of the eyes. When the tears cannot be pressed out from the punctum, by vigorous pressure on the lachrymal sac, there will be doubt as to whether the sit-

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[1] "Treatise on the Eye," page 282.

uation of the excessive secretion may not be in the conjunctiva, and there be no stricture in the lachrymal passages. It is not necessary that there be marked conjunctival hyperæmia. Where this is the case, a nasal catarrh sometimes co-exists, with a general watering of the eyes, and yet there may be no obstruction in the puncta, sac, or ducts.[1]

The surgeon will very properly exercise considerable discrimination before resorting to what is always a very painful procedure, dividing the canaliculus and probing the nasal duct.

The prolonged use of hot-water fomentations, by means of absorbent cotton, say for ten minutes at a time, every two hours, will sometimes render surgical interference unnecessary.

One of the eyelashes may enter the lachrymal punctum, and become a source of annoyance the cause of which is sometimes overlooked. Such patients complain of sensations as if something were in the corner of the eye, and a close examination will reveal the cause of the trouble.

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[1] "Pathological Weeping," Osborne, June 4th, 1891.

CHAPTER XIII.

INJURIES AND DISEASES OF THE CONJUNCTIVA.

Foreign Bodies upon the Conjunctiva.—Eye-Stones.—Injuries from Lime, Mortar, Acids.—Sub-conjunctival Hemorrhage.—Œdema.—Emphysema.

FOREIGN BODIES.

Foreign bodies upon the conjunctiva are not usually matters of serious consequence. They are easily removed, and they leave little behind, if the removal be prompt and timely, troublesome as they may be for the victims of them. The most frequent source of their coming upon the conjunctiva, is railway travel, and they are then usually cinders from the locomotive. On windy days, however, any small particles that may be flying about the air may lodge in the conjunctival sac; such are very small pieces of stone from stone cuttings, sawdust, grains of sand, and the like. As a preliminary examination for any case of suddenly occurring pain referred to the conjunctiva or eye in general, a search for a foreign body is always in order. The most minute bodies, only to be detected by acute vision, aided by artificial light, and a convex glass, may cause considerable pain, with an attendant sense of something scratching the eye, photophobia, and lachrymation. On the other hand, patients who have lately suffered from the presence of a foreign body on the conjunctiva, which has found its way out with the rubbing generally practised, or from the flow of tears excited by it, often seek an examination to determine if a foreign body be not in the eye, the sensation immediately after the removal sometimes being nearly as unpleasant as when the foreign body actually was there. In not a few cases, during the treatment of trachoma, or conjunctivitis, foreign bodies have been found in the conjunctiva which have been overlooked by previous examiners, and upon which inflammation has supervened, and covered up the source of trouble. In

one case at the hospital, a bit of wood at least one-half of an inch long was found buried in the trachomatous tissue of the upper lid. In another, in private practice, that of a child, who had been climbing a cherry tree a week before, a bit of branch of the tree had been lodged under the lid, and remained there while the patient was being treated for an inflamed eye, by a practitioner who had neglected to thoroughly examine the conjunctival sac.

One exception must be made to the statement that foreign bodies are easily removed from the conjunctival sac. Grains of powder, such as get into the face from accidental explosions, must often be removed by tedious picking at the conjunctiva or by cutting them out. Usually, however, foreign bodies are removed, by lifting them up from the conjunctiva with a bit of soft muslin, a handkerchief, a spud, or the like. If the foreign body be buried in the conjunctiva, it is of course necessary to instill a solution of cocaine before manipulating. The method of everting the upper lid easily and without inflicting pain upon the patient has been already described in Chapter VII. The surgeon should make himself perfect in this small but important operation, before setting out to practise, even if he be not specially devoted to the treatment of diseases of the eye. The general practitioner stands in as much need of knowing this manipulation, as does an ophthalmic surgeon.

It is well to caution patients not to use so-called eye-stones, to remove foreign bodies. When they are efficacious, it is by very clumsy and not entirely safe means, for they remove the foreign body by placing another in, which excites a great flow of tears, which if strong enough sometimes dislodges the foreign body, and brings it out. Patients if not able to learn to evert their own lids, may rub the upper lid downward for some moments. This manœuvre is often sufficient to dislodge a foreign body.

INJURIES FROM LIME, MORTAR, ACIDS, AND SO FORTH.

Unfortunately for the patient, these are not generally immediately seen on their occurrence by a surgeon. But if they were it would not be always in time to prevent serious consequences from the burning of the conjunctiva and cornea. The

fellow-workmen of the patient, usually have enough knowledge to make a proper application, that will limit in some degree the deplorable consequences of such an injury.

Treatment.—When lime or a similar caustic alkali enters the eye, it should be immediately neutralized by a weak acid. Vinegar is very efficacious and generally convenient. Oil should then be freely used to keep the parts well lubricated and thus diminish the pain. If the cornea have been injured, or the conjunctiva very severely hurt, a solution of atropia, gr. ij. to gr. iv. ad ℥ i., should be instilled, two or three times in twenty-four hours. Cold applications will be usually grateful for twenty-four or forty-eight hours after such injuries.

Traumatic conjunctivitis does not usually occur in the purulent form, and with very simple treatment, it subsides without doing permanent injury, unless the wound or burn has been deep enough to destroy the conjunctiva, when symblepharon may result. If the conjunctiva or cornea be deeply or extremely burned, symblepharon will be sure to occur in the former case, and opacity of the cornea in the latter, in spite of most intelligent and careful treatment.

The cases of lime in the eye, after the removal of the foreign body, should be considered as cases of kerato-conjunctivitis and be treated according to the severity of the symptoms. The use of astringents is to be avoided. In some rare cases heated metal may be splashed into the eyes, and yet do very little harm. In such instances, the metal cools very rapidly, instantaneously forms a lining to the conjunctival sac and a cover to the cornea, which may be lifted off by a probe. A chamber has formed in consequence of the steam arising from the melted metal, which protects the conjunctiva and cornea, from that which would otherwise burn its tissue beyond repair. These fortunate cases seem very remarkable; one opens the closed lids and lifts off the shell of metal, expecting to find the tissue destroyed beneath, yet happily it is well protected, and nothing but a mild form of conjunctivitis results.

SUB-CONJUNCTIVAL HEMORRHAGE.

This is not an uncommon occurrence as a consequence of rupture of the vessels of the conjunctiva, without previous injury.

By itself it is a disease without any special significance, as it occurs with no other lesion in the body in young and old, feeble and strong alike. It may occur, however, after very violent exertion, like sneezing, coughing, and so forth. It is sometimes a symptom in scurvy and Bright's disease. It may also occur in nervous exhaustion, and as a result of strain of the accommodation in uncorrected refractive anomalies. The prognosis or significance of each case is to be judged by itself, for it may mean nothing of vital importance, and it may be on the other hand an indication of serious deterioration of the blood-vessels. Naturally it is a symptom that may arise from operations upon the eyeball or muscles, or from injuries of the orbit.

Treatment.—Cold water applications followed by slightly stimulating lotions are comfortable to the patient, and they may hasten the absorption of the effused blood, but the latter is not certainly known. Many cases seem to me to get well without especial treatment, as fast as when lotions are used.

Œdema is a symptom occurring in various forms of conjunctival disease or injury. It may also be a senile change, and occur in advanced Bright's disease. A compress and bandage are useful in extreme cases.

Emphysema of the conjunctiva, sometimes occurs from fracture of the nose, and from lachrymal disease. The swelling is characterized by crepitation. A pressure bandage may be applied if the symptom be troublesome. If this is done, it should be removed at least twice in twenty-four hours, lest it be doing harm, or lest other applications be called for. Serious cellulitis may possibly be caused by the undue tightness of a bandage in such cases.

CHAPTER XIV.

INFLAMMATORY AFFECTIONS OF THE CONJUNCTIVA.

Classification of Conjunctivitis.—A Healthy Conjunctiva.—Catarrhal Conjunctivitis, Causes, Treatment.—Blennorrhœa.—Purulent Inflammation or Pyorrhœa.—*Ophthalmia Neonatorum.*—Gonorrhœal Conjunctivitis.

THE inflammatory affections of the conjunctiva are divided naturally into the following forms:

Hyperæmia. Catarrhal inflammation. Blennorrhœa. Pyorrhœa or purulent inflammation. Granular conjunctivitis (trachoma). Phlyctenular conjunctivitis. Diphtheritic conjunctivitis.

Hyperæmia, that is to say, an enlargement and increase in the number of the blood-vessels of the conjunctiva, without increase of the secretion, is usually either symptomatic of uncorrected refractive anomalies, the recent presence of a foreign body, or of the onset of an inflammation. The cause should be carefully sought out, and the treatment be directed accordingly. It is, I think, sometimes possible to abort an imminent inflammation of the conjunctiva, by timely applications of iced cloths, and an application of a solution of nitrate of silver, say ten grains to the ounce. Hyperæmia of the conjunctiva, sometimes results from permanent conditions and is incurable. It is sometimes the intimation of coming iritis, after cataract extraction, but slight conjunctival hyperæmia is the rule, after this operation, and after an iridectomy, whether iritis occurs or not. It is important here, as elsewhere, in surgery that the practitioner accustom himself to the examination and mental description of a healthy conjunctiva. The characteristics of a healthy conjunctiva are:

1. Light salmon color.

2. The individual vessels may be traced out in the upper and lower palpebral conjunctiva.

3. At each canthus the redness is more dense, that is to say, the vessels are more numerous.

4. The conjunctiva of the lids has a smooth silky appearance, so that it appears as smooth as the surface of a delicate serous membrane, like the peritoneum.

CATARRHAL CONJUNCTIVITIS.

The characteristics of catarrhal conjunctivitis, are a network redness of the conjunctival vessels, an increased secretion of mucus, with perhaps a reddish line along the edge of the lids, involving the Meibomian follicles.

A classification of the various forms of conjunctivitis is in its very nature an artificial one, for one form may run into the other, two varieties may occur at the same time, and apparently different causes may produce diseases not to be distinguished from each other. The above may be considered the characteristics of an average case. In the present state of the germ theory of disease, it is impossible to say that the specific bacillus found in the secretion of the conjunctiva, in the particular form of inflammation, is or is not the essential cause of the disease. There must not only be a specific germ to cause a disease, but also a soil in which it is to grow. Certain it is that all inflammations of the conjunctiva are contagious, and that the contagious property increases in intensity, in the ascending forms. Blennorrhœa is more highly contagious than catarrh, and pyorrhœa more than blennorrhœa. The older an inflammation of the conjunctiva, the less intense its contagious properties. From a clinical standpoint, catarrhal conjunctivitis is characterized by increased secretion from the conjunctiva, and enlargement of its blood-vessels. In the form, unmixed with phlyctenular disease, and occurring in persons in good strength, there is very little photophobia, and no running out of the tears in a stream, when the lids are forcibly opened. As a matter of fact the patient opens the eyes readily in the simpler forms of the disease, that is, without dread of light. The lids become easily glued together at night, and it is with difficulty that the patient opens them, after sleep.

Causes.—The exciting causes of catarrhal conjunctivitis are

numerous. Contagion stands in the front rank. If one scholar in a school, or one member of a family, contracts the disease, unless great care is exercised, many or all the members of the same school or family will become affected. The contagious property may be in the air, and deposited from one conjunctiva to another. It may more commonly be introduced by the improper habit of different persons using the same towels, occupying the same bed, or the like. It is a disease which sometimes is epidemic in communities. It is generally known as "pink eye," when this occurs. Spring catarrh, is also a name used by the Germans to designate this epidemic form of catarrhal conjunctivitis. It is also excited by strain of the accommodation, by long-continued occupation upon fine objects, especially in persons whose eyes are not entirely sound, or in those who have errors of refraction, worthy of correction, and who do not use glasses. How to reconcile this with the claim that in every case there is a specific germ, causing an inflammation, it is impossible for me to say. I am inclined to the opinion that the germs may exist in healthy eyes, and be excited into activity by mechanical or chemical causes. A. Jacobi (New York) goes so far as to say that diphtheria cannot occur in a sound mucous membrane; in other words, that a soil for the disease must be prepared before the germ will act. This opinion I indorse.

Tobacco smoke, dusty places, strong wind, the glare of the sun, excessive indulgence in spirituous drinks, all become causes of catarrhal conjunctivitis, although in certain persons they may only cause hyperæmia of the conjunctiva, while in others a true inflammation is produced. Catarrhal conjunctivitis, especially in its acute form, is very amenable to treatment. In fact it is a self-limited disease in many cases. When it becomes chronic and depends upon causes that cannot easily be removed, it is often incurable.

Treatment.—In mild cases of acute conjunctivitis this may be entirely expectant, as far as local applications are concerned. The patient should simply desist from any occupations or abode that may conduce to increase or maintain the inflammation of his eyes. He should go about in the fresh air, protect the eyes with a broad-brimmed hat or veil or colored glasses, from bright light or wind if necessary. If the light is not disagreeable and

there is no wind, very little protection will be necessary. Under such hygienic care, together with the use of a solution of salt and water, or boric acid and water, or pure water alone, for cleansing the eye, and smearing the edge of the lids at bedtime with a little benzoated lard or vaseline or cold cream, or simple cerate, the secretion diminishes in a few days, the congestion disappears, and the patient has fully recovered. But each case must be studied by itself. Some cases, although not severe, will not disappear under expectant treatment. Then local means must be employed. The cause for the attack must of course be searched out, and removed if possible. The use of a ten-grain solution of nitrate of silver carefully brushed on the palpebral conjunctiva will, at times, cut short an attack of catarrhal conjunctivitis of a mild type. This should be followed up by the instillation of a solution of alum, one to two grains to the ounce, or a solution of sulphate of zinc in the same strength by the patient. These two agents form the best means of abating the congestion in acute catarrhal conjunctivitis. The use of bichloride of mercury is of late very much advocated, on account of its supposed properties as a germicide, but it is not certain but that alum and the sulphate of zinc, have the same qualities, as far as antisepsis or asepsis is concerned. They have stood the test of a century of trial, and are well worthy of the confidence heretofore reposed in them, whatever may be the principles upon which they act. Alum in crystal, tannic acid and glycerin, a spray of tannic acid and borax and camphor are better adapted for chronic or exceedingly mild forms of catarrhal conjunctivitis. Cold applications, iced cloths, or very hot water may be used by the patient during the day, according to the severity of the subjective symptoms, such as sensations of sand, sticks, foreign bodies in the eye, heat, burning, and so forth. After the subsidence of an acute catarrhal conjunctivitis or during the course of a mild or chronic form of the disease, the refraction should be examined, especially as to the existence of hypermetropia or astigmatism. For just as it is the last straw that breaks the camel's back, so a strain of accommodation is often the predominant factor in the production of an attack of catarrhal conjunctivitis.

BLENNORRHŒA.

The characteristics of blennorrhœa of the conjunctiva, are considerable swelling, with a reddish tint of the integument of the lids, and a great increase of conjunctival secretion of a muco-purulent character.

It is sometimes hard to draw the line between catarrh and blennorrhœa, and yet it should be carefully drawn by every practitioner, if he would do full justice to his case. In pure catarrh only mucus is secreted by the conjunctiva: in blennorrhœa, mucus and pus are secreted. The greater the production of pus the more urgent is the case, but in any event blennorrhœa is a serious disease, which may at any moment advance to be a pyorrhœa and destroy or injure the cornea and the sight. A case of blennorrhœa should be treated with much more circumspection and zeal than one of catarrh. The swelling of the lids, the congestion of the conjunctival vessels will be much greater, the secretion more copious and dangerous. It will be well, therefore, to keep the patient entirely away from his usual occupations, perhaps allowing him to go into the open air, at stated intervals. While he is lying down, iced applications should be made to his closed lids, for fifteen to thirty minutes continuously, every one, two, or three hours according to circumstances. He should if possible have an attendant, and he and his belongings should be quarantined from all persons with sound eyes; the greatest precautions should be taken with all the instruments and applications made to the eye, to secure cleanliness, and prevent contagion. The absorbent cotton and old linen, used in making the applications, should be burned after use, and all the patient's underclothing should be carefully kept apart from others in washing, while the laundress is warned of its dangerous character. Nitrate of silver in solution, from five to twenty grains to the ounce, should be applied to the palpebral conjunctiva, once or twice a day, by the surgeon; while a solution of alum, two grains to the ounce, may be used by the nurse or the patient himself as a collyrium. If great pain occur, which is not readily controlled by the iced cloths, hydrochlorate of cocaine, eight grains to the ounce, should be dropped into the eyes according to circumstances. When using cocaine for pain, the eyes should

be flooded with it. This requires the use of from ten to thirty drops at each instillation. If necessary, on account of pain, morphia may be given at night, but this is not often required. Boric acid in the water for washing the eyes is more bland than ordinary water. As the swelling of the lids and other symptoms abate, the iced cloths and nitrate of silver should be discontinued, and a crystal of alum used by the surgeon on the everted lids, or a solution of the same, by the patient. The lids should be smeared with benzoated lard or vaseline at all stages of the disease, after applications are finished. If the conjunctiva remains thickened or trachomatous, after the violent stage of the disease has subsided, this should be carefully treated, until complete recovery has resulted. Much trachoma has occurred from neglected catarrhal conjunctivitis and from the advanced stages of the disease.

PURULENT CONJUNCTIVIS—PYORRHŒA.

The characteristics of purulent inflammation, are great swelling, tension, and redness of the integument of the lids—so that the eyes can be scarcely opened by the patient himself, —great redness of the conjunctiva, with a band-like swelling around the cornea and a very abundant purulent secretion.

The picture of this condition of the conjunctiva, of purulent ophthalmia or purulent conjunctivitis, is but a highly drawn one of blennorrhœa. The lids are very much swollen; at the height of the disease they are so tense, that it is with great difficulty that they can be opened; when held apart, by the fingers or an elevator, the pus streams out thicker and more yellow, according to the vigor of the patient and the stage of the disease. The lids are sometimes of a brilliant red color, the whole conjunctival surface is swelled and brawny, no trace of individual vessels is to be seen, and around the cornea it is lifted up, so as to form a wall about it (chemosis). The cornea in the early stages is brilliant, but it is very apt to become involved, its epithelium removed, and if the progress of the disease be not checked, its structure breaks down entirely. An ominous signal of the occurrence of this is a line around the margin of the cornea of infiltration and softness, which presages, if not the ruin, at least the great injury to the sight.

PURULENT CONJUNCTIVITIS IN INFANTS.

This disease, when occurring in infants, is known as the ophthalmia of the early born—ophthalmia neonatorum. Although the same disease in character as that occurring in older subjects, it deserves especial mention and description. It usually begins, as will be seen, if the eyes are carefully examined, at birth, as a mild inflammation, but if unchecked it advances very rapidly, and in forty-eight hours it may be at the height of its severity, where it will remain for some days. The symptoms are those that have just been narrated. In some cases they are less severe, when the case may be fairly called one of blennorrhœa only. The origin of purulent ophthalmia in infants is probably always from the secretions of the mother's genitals, although it is to be conceived that a child might be born with sound eyes, that are protected by the amnion, and that they may become infected by the dressings or the hands of the nurse, which, however, have been infected by the secretions of the mother.

Treatment.—Preventive treatment of ophthalmia neonatorum. The practitioner should take great care of all women with leucorrhœa, who are about to be confined, use local antiseptics. Credé advises a two-per-cent solution of nitrate of silver to be dropped into the eyes of all the newly born immediately after birth, and Garrigues (New York) indorses this view from a large experience in lying-in-hospital service and private practice. Schmidt-Rimpler advises chlorine water instead of nitrate of silver, as being less irritating. Certainly all precautions should be taken. This abortive treatment has reduced the percentage of purulent ophthalmia in lying-in hospitals, especially in Maternity hospitals. If the disease has once appeared it may be a mere catarrh, or very mild blennorrhœa, which is easily subdued by cleanliness with boric acid and water, ointments to the lids, and general hygiene. But if the disease be actually a severe one of blennorrhœa, or if it be of an entirely purulent character, the surgeon will require all his resources, lest the cornea become invaded, and the infant lose its sight. As soon as the formation of pus occurs in any quantity, thorough cleanliness must be the watchword. This is best attained by the use of absorbent cot-

ton, dipped in a solution of boric acid in tepid water. The little patient should be held upon the surgeon's lap for the purpose, he being thoroughly protected by napkins and so forth. It may be said here that there is especial danger, in all cases of blennorrhœa or pyorrhœa, that the surgeon or attendant may infect himself by the transference of material from the patient's eyes to his own. This is especially apt to occur, if the surgeon is not careful in opening the lids at each new examination of the patient, or in syringing out the conjunctival sac. If a surgeon have many patients to see, unless he can count upon himself to be always on his guard, he may wear large, protective glasses.

A mild form of blennorrhœa of the conjunctiva, associated with trachoma, may be chronic and epidemic, when large numbers of children are together in large cities, as in orphan asylums, large schools, or the like. It sometimes invades armies, and incapacitates as many as a battle.

GONORRHŒAL CONJUNCTIVITIS is of the same form. It is impossible to distinguish it from any purulent conjunctivitis, except by the specific gonococcus, and it is not absolutely settled that it may then be from purulent conjunctivitis or blennorrhœa arising from other sources of contagion. It is probable that some cases, where we are unable to trace the contagion, the patient not being affected with gonorrhœa at the time, or never having had it, are really due to this cause. Although there may be a few cases of purulent conjunctivitis here and there, that have advanced by evolution as it were, from ordinary catarrhal conjunctivitis to blennorrhœa and pyorrhœa, the vast majority of the severe forms of catarrhal conjunctivitis may be traced to contagion.

There was an interesting case tried in one of our courts, a few years ago, when a mild blennorrhœa or catarrh, with trachoma, suddenly on exposure to a cold wind became a purulent inflammation which destroyed the eye. The prosecution claimed that the eye was lost from contagion with an infected brush. But as it was shown that the brush used was dipped in nitrate of silver, before being applied to the conjunctiva, that it was properly held, that there could be no contagion from such a source, even if it had been previously used in a case of blennorrhœa, which was not shown as admitted. It was properly held

also that the advance from trachoma to blennorrhœa and purulent inflammation could easily be made under no other provocation than undue exposure.

In our time, camel's-hair brushes have been superseded by absorbent cotton for all applications to the conjunctiva, and even the suspicion of contagion by the use of the same brush on different patients is avoided.

The treatment of purulent conjunctivitis in adults is the same in principle as that in infants—absolute cleanliness at the hands of a trained attendant, if possible, cold applications until the swelling and redness of the integument of the lids begin to abate; after that ten grains nitrate of silver in solution, not the solid stick of nitrate of silver, or nitrate of silver and nitrate of potash, with the use of mild astringents and soothing instillations during the day. The vaseline treatment introduced by Dr. F. M. Wilson, of Bridgeport, has many advocates. In this treatment the conjunctival sac is kept filled with vaseline, after cleansing and applications have been made.

Snipping the vessels of the conjunctiva, especially those about the cornea, where great swelling of the ocular conjunctiva occurs, is an old-fashioned mode of treatment, which I find of some avail.

The importance of the subject may justify a tabulation of the treatment:

TABLE TO SHOW TREATMENT OF PURULENT CONJUNCTIVITIS.

EARLY STAGES.

1. Hourly cleansing of the conjunctival sac with absorbent cotton, and saturated solutions of boric acid or borax and water.
2. Cold applications by iced cloths.
3. Free use of vaseline to the lids and surroundings.

LATER STAGES.

1. Daily applications of nitrate of silver, gr. v. or x. ad ℥ i., or frequent (every two hours) applications of $\frac{1}{480}$ grain to the ounce, in spray, until the epithelium of the cornea is coated.
2. The dropping in of astringents by the attendant.

At the same time the patient's general condition should be carefully attended to, especially with reference to the nutrition.

It may be of service in the early days of excessive tension of the integument, to divide it by a canthotomy, or to cut the lid vertically. If the cornea begins to be invaded, the use of atropia is indicated. As the disease passes into the less severe stages, the treatment should of course be moderated, and that for catarrh or mild blennorrhœa substituted.

Dr. Buller, of Montreal, recommends that the sound eye in adults be protected by a large glass shield, like the crystal of a watch, which is fastened over the eye by two layers of rubber plaster. This leaves the sound eye still to be used. We have found this method of protection very useful in the Manhattan Eye and Ear Hospital.

STATISTICS.

Dr. A. E. Davis[1] carefully collated the statistics of nine ophthalmic institutions in the United States, for the purpose of learning the proportion of contagious conjunctival disease to other forms. This table shows that in over half a million of cases of diseases of the eye, 27.5 per cent, or 140,755, are contagious, as follows:

	Number.	Contagious diseases.	All diseases.
		Per cent.	Per cent.
Contagious diseases	140,755	......	27.50
Conjunctiva catarrhalis	108,778	77.28	21.25
Conjunctiva granulosa	21,757	15.46	4.25
Conjunctiva granulosa, with pannus	4,178	2.97	.82
Conjunctiva purulenta	2,678	1.90	.52
Conjunctiva neonatorum	2,374	1.69	.46
Conjunctiva gonorrhœica	638	.45	.12
Conjunctiva crouposa	86	.06	.017
Conjunctiva diphtheritica	266	.19	.052

Dr. Davis' paper also gives interesting statistics as to the results of treatment in 38 cases, taken from those last under treatment at the time his paper was written, under the care of my colleagues, Drs. Pomeroy, Webster, and Emerson, and myself. Eighteen of these were treated for conjunctivitis gonorrhœica; 4 for conjunctivitis neonatorum, 16 for purulent conjunctivitis—in all 38 cases. Of the 38 cases 23 were males, 15 females; 18 had both eyes affected, 22 one

[1] Medical Record, July 11th, 1891.

eye affected, making 58 eyes in the 38 cases. Seventeen of the cases were seen during the first week, the remainder any time from eight days to thirty days after the eyes were affected. Of the 58 eyes 22 had clear corneæ, 36 had either ulcerated, perforated, or sloughed corneæ. Out of the 22 eyes with clear corneæ 15 made perfect recovery without the cornea being implicated; 1 ulcerated, 4 perforated, 2 sloughed. The one that ulcerated obtained $\frac{20}{100}$ vision. Of the 4 that perforated 1 obtained $\frac{20}{50}$ vision; 1, $\frac{20}{70}$; 1, $\frac{3}{200}$; 1, perception of light. Of the 2 that sloughed, 1 perception of light; 1, nil. To recapitulate: Out of 22 eyes with clear corneæ, 15 obtained perfect vision, 4 useful vision, 2 perception of light, and 1 only absolutely lost.

Of the 36 affected corneæ 20 had perforated, 9 had ulcerated, and 7 had sloughed. The 4 ophthalmia neonatorum cases furnished 3 of the eyes with affected corneæ—1 had an ulcer which left a slight opacity, the other 2 had perforating ulcers which left opacities with anterior synechiæ. The remaining 33 eyes with affected corneæ were in adults. Eight had ulcers, 18 perforation with anterior synechiæ, 7 had sloughs. Of the 8 eyes with ulcers 1 obtained vision $\frac{20}{70}$; 1, $\frac{20}{15}$; 1, $\frac{20}{30}$; 1, $\frac{20}{100}$; 1, $\frac{3}{200}$; 1, $\frac{18}{200}$; 1 fingers at eighteen inches; 1 perception of light. Of the 18 with perforations 12 obtained perception of light; 2, fingers at eighteen inches; 1, $\frac{6}{200}$; 1, $\frac{14}{200}$; 1, nil; 1, unstated. Of the 7 eyes with sloughed corneæ vision was nil, or 0, in all of them. We have therefore in the 36 eyes with affected corneæ 1 with perfect vision—$\frac{20}{15}$—in the case of a man with gonorrhœal ophthalmia contracted from acute gonorrhœa from which he was suffering at the time; 8 with useful vision; 3, fingers at eighteen inches; 13 with perception of light, and 8 with absolute failures. Three of the 36 eyes were ophthalmia neonatorum in children, above noted.

Recapitulation.—Upon the 58 eyes treated for gonorrhœal ophthalmia, purulent ophthalmia, and ophthalmia neonatorum, perfect recovery resulted in 16 cases, or 27.59 per cent; useful vision in 11 cases, or 18.96 per cent; perception of light in 15 cases, or 25.86 per cent; fingers in 3 cases, or 5.17 per cent; opacities and synechiæ (in children) in 3 cases, or 5.17 per cent; absolute failure in 9 cases, or 15.52 per cent; unstated in 1 case, or 1.73 per cent. The youngest subject—excepting the ophthalmia neonatorum cases—was a boy, seven years of age, and the oldest, a woman, sixty-five years of age.

The statistics of Dr. Davis, illustrate fairly well the dangerous character of contagious conjunctivitis, especially of blennorrhœa

and pyorrhœa, and what may be expected from proper and assiduous treatment.

The prognosis in blennorrhœa and purulent conjunctivitis depends largely upon two factors:

1. The general condition of the patient.

A poorly nourished infant, of feeble parentage, or a depraved young subject with gonorrhœal conjunctivitis, will have a poor chance of escaping without a serious lesion of the cornea; while a vigorous child, or a healthy young subject, who has contracted the disease while attending another case, a nurse or a surgeon, for example, will have a much better chance.

2. The invasion of the cornea. If the cornea be attacked before proper means of thorough treatment have been resorted to, the chances of recovery with sound eyes will be very poor.

The importance of this subject of contagious ophthalmia has led to a law in the State of New York, making it a misdemeanor if a midwife fail to report the occurrence of *sore eyes* in an infant she has delivered.

Hospitals for contagious diseases of the eyes should be established in large cities and towns, and undoubtedly will be when our civilization has reached a sufficiently high stage. So dangerous are these diseases, that the ordinary patients in great hospitals, are in danger, if the wards devoted to purulent conjunctivitis are attended by the same nurses, servants, and surgeons.

CHAPTER XV.

CONJUNCTIVITIS.—(*Continued.*)

Diphtheritic Conjunctivitis.—Membranous Conjunctivitis.—Phlyctenular Conjunctivitis.—Granular Conjunctivitis.—Trachoma.—Pterygium.—Xerophthalmia.—Symblepharon.—Anchyloblepharon.

DIPHTHERITIC CONJUNCTIVITIS.

DIPHTHERITIC conjunctivitis is very rare in the United States and also in England. It is more frequently seen on the continent of Europe, in the clinics of Germany. Only very rarely does a case appear in the Manhattan Eye and Ear Hospital. Statistics in the year 1891–92 show that among nearly ten thousand eye cases, not one case of diphtheritic conjunctivitis was found. The disease is closely allied in character to membranous conjunctivitis, and occurs chiefly in young children. It is remarkable, when we consider the frequency of diphtheria in New York, that we so rarely have to treat diphtheritic conjunctivitis.

Symptoms.—The disease is readily recognized. There is a yellowish-white membrane upon the palpebral conjunctiva in a weak and cachectic subject. There is considerable swelling of the lids, but the secretion is slight or none. The lids are excessively tender and hard. There is fibrinous infiltration, which causes the characteristic rigidity, and the pale, smooth, glistening surface of the conjunctiva. The grayish-white membrane may be stripped off. Flakes of lymph are also discharged. As recovery ensues the parts soften, from the disappearance of the fibrinous matter, and pus forms. There is a great tendency to cicatrization of the tissue in the recovery from diphtheritic conjunctivitis.

Treatment.—Since this is a constitutional affection, local treatment is not so effective as in the other forms of conjunctival disease. While the patient receives great care as to his general condition by nutrients and stimulants, hot or cold applications, as may be most comfortable, are made to the closed

lids. The scanty secretions are removed with absorbent cotton, dipped in a saturated solution of boric acid, and an ointment is applied to the edge of the lids, at night especially, as in all conjunctival affections. The cornea is apt to be invaded in the course of the disease. Atropia or scopolamine is therefore to be used from the start.

MEMBRANOUS CONJUNCTIVITIS.

This is much more common than diphtheritic conjunctivitis, and is sometimes mistaken for it. It is really a degenerative form of catarrhal conjunctivitis. Like the diphtheritic inflammation, it occurs in subjects somewhat run down in general health. It may be distinguished from true diphtheritic conjunctivitis by the fact that the membrane readily peels off, the conjunctiva and connective tissue are not so tense, thick, and tender, and the constitutional symptoms are not so grave.

Treatment.—Cool applications, frequent cleanings, mild astringents, collyria of alum or zinc are indicated, with especial hygienic care of the general system.

PHLYCTENULAR CONJUNCTIVITIS.

(*φλυκταινα*, pimple.)

This disease is very common among the poorly fed and poorly nourished children in large cities. In 1891–92, in the Manhattan Eye and Ear Hospital, in a total of 9,720 cases of diseases of the eye, of which 2,293 were diseases of the conjunctiva, there were 188 of phlyctenular conjunctivitis, and 198 of phlyctenular keratitis.

Phlyctenular disease also occurs amid good general hygienic surroundings, in children in whom local hygiene is neglected, and the general nutrition is consequently affected. Its existence is an index of the general condition, especially of the nutrition.

Phlyctenular diseases may be seen among children living in the best of country air, but just as the peasantry of Switzerland may not avail themselves, or on account of poverty may not be able to avail themselves, of the immense advantages of their life in pure air, and by their improper diet and neglect of general hygienic laws may have unhealthy offspring, just so

in our country this disease of malnutrition is sometimes seen amid proper surroundings, but where all the laws for the preservation of health are violated.

PHLYCTENULAR CONJUNCTIVITIS *is characterized by great photophobia, lachrymation, and the presence in the conjunctiva of little nodules of inflammation, small yellowish-red elevations, the so-called phlyctenules, on whose summit a vesicle forms, which bursts and leaves a small ulcer or a collection of blood-vessels; one or more of these vesicles may occur. The lids are lightly clinched, and when they are forcibly opened, there is a great gush of water.*

Proper air, frequent bathing, good food, and general hygiene are the antidotes to this disease. It is one that is unknown among properly fed and nourished children. It is dangerous because the same disease is very often engrafted upon the cornea, where ulceration, even when recovered from, is a serious matter. It also, like membranous conjunctivitis, begins as a bastard catarrh of the conjunctiva. In puny and badly nourished patients, a simple catarrh soon takes on this form. Probably this is due at times to the unchecked habit of rubbing the eyes with soiled hands, and grinding in the dirt upon the hyperæmic conjunctiva. It is not to be denied that phlyctenular conjunctivitis may at times occur in robust, red-cheeked children, but this is very rare. Even when it does so occur, over-feeding or the like and not a mere local irritation has been the fault.

Treatment.—This should be divided into local and constitutional. Neither ought to be omitted, and yet such cases recover with general hygienic care alone.

If any of my readers have ever studied conjunctivitis in homeless animals, such as stray dogs or cats, by transferring these creatures where they get sufficient food and proper shelter, he will appreciate the importance of hygienic care alone, in the cure of local diseases. In several instances, I have had an opportunity to watch the disappearance of conjunctival disease in domestic animals, who have been rescued from neglect and hunger, and placed where their natural wants were fully satisfied. Without local applications of any kind, they have invariably recovered. No doubt, in their own habits of lubricating their eyelids, when they are at all contented, may be found an efficient

local application, so that it cannot be positively said that, even here, local influences have not been at work in promoting a cure. But, certainly, in such cases general hygiene has done the chief work.

If the photophobia be a very marked symptom, so that the eyelids are clinched together and can only be opened by force, when a great gush of water occurs, the cold douche is very useful and often is of immediate service. It is a harsh remedy, and since the introduction of cocaine into practice, especially in mild cases, I substitute the latter for the douche, and if it be not effectual, I then resort to the cold douche. An ointment should be used on the lids, and if the usual accompaniments of the severe cases, eczema and nasal catarrh, are present, it should be used on the face and in the nose also. Sulphate of atropia, gr. ½ to ij. ad ℥ i., is to be instilled once to three times a day.

Among my patients at the Hospital, where I almost exclusively see these cases, I prescribe cod-liver oil for rubbing in the face, and I use a solution of tannin and glycerin in the nostrils on account of the nasal catarrh, which is usually very marked. The moment the surgeon begins to examine such a case as he should, holding the child's head on his lap and between his knees, and attempts to open the puffy lids, the little patient begins to sneeze and a great gush of water comes out of the conjunctival sac.

The insufflation of calomel comes next, for there is much local treatment necessary in the treatment of phlyctenular disease. Cocaine should also be used, until the acute symptoms, especially the photophobia, have subsided. The ointment of the yellow oxide of mercury may be used instead of the calomel. It is praised by Jonathan Hutchinson (London) and others as a specific. It is certainly a remedy of inestimable value: a small portion on the end of a spatula is placed between the lids and well rubbed in by the fingers of a surgeon, or attendant.

In most cases of phlyctenular conjunctivitis, it will be found that much is to be done through general care of the system, and yet in the most instances, in our large clinics, where these cases are numerous, it will be impossible to accomplish very much for the general hygiene of the squalid and neglected homes from

which the patients come. In these are to be found the causes of the great prevalence of this and other forms of conjunctival disease among the children of the poor. Yet the practitioner should not fail to give elementary instruction on such matters as diet, bathing, and so forth, to the parents of such children. The parents are very prone to improperly feed their young children. They give them the "run of the table," stuff them with tea and so on, to the neglect of a milk diet so advantageous to children under eight years of age. Indeed if the whole community could be induced to bring up their children on milk and farinaceous diet until the second dentition is accomplished, great benefit to the general nutrition, with a corresponding immunity from disease, would result. Yet, as I have already said, children of the classes able to care properly for them are also affected with phlyctenular conjunctivitis. With them, it will also be well for the surgeon to impress the necessity of hygiene as the fundamental matter to be considered, in the prevention of a disease that may destroy the sight.

GRANULAR CONJUNCTIVITIS.—GRANULAR LIDS.—TRACHOMA.

(*τραχωμα*, a roughness.)

This disease is characterized by the appearance of small prominences, uneven in shape, thickly crowded together, in a swelled, round, and vascular conjunctiva. These appearances are confined to the palpebral conjunctiva. They are sometimes hypertrophied papillæ, and again diffused vascular excrescences resembling condylomata, arranged in rows and looking like roundish granules. They are sometimes of the same color with the conjunctiva and not much elevated above the surface, but again they are very prominent, and in shape and gelatinous translucency resemble the spawn of fish or frogs (Stellwag).

The above description, which is essentially that of Stellwag (Vienna, 1870), comprehends almost, if not all the various forms which trachoma may assume. The name trachoma is much to be preferred to that of granular lids or granular conjunctivitis, since it conveys a better idea of the pathology of the disease, or rather does not commit us to any pathology, but simply indicates the chief objective symptom, the roughness of the conjunctiva.

Trachoma is generally a chronic disease, the result of a conjunctivitis that has run its course. Investigation usually shows that there was at first an ordinary catarrhal conjunctivitis from which this sprang. Among careless people, or improperly cared-for children, the occurrence of the acute conjunctivitis is often forgotten, and the trachoma is believed to have originated without any such antecedent and rather more acute disease. Trachoma may appear, for example, after blennorrhœa or purulent inflammation of the conjunctiva, and remain for some weeks. This form of trachoma is much more amenable to treatment than the more chronic forms.

The roughness arising from acute catarrhal and blennorrhœal conjunctivitis readily subsides under treatment and soon disappears. This form of the disease is manageable, and responds easily to proper treatment, but when chronic trachoma is reached, it is otherwise. It becomes readily epidemic in asylums and schools and camps, and is a disease from which it is often impossible for the patient to recover perfectly. To reduce it even to a bearable condition, will often require all the resources of our art. From the definition of the disease, or the sketch of its appearance, which is placed at the head of this chapter, it must occur to the reader that classification may be made of the various forms of trachoma.

Stellwag divides them as follows:

1. Pale granular.
2. Papillary.
3. Mixed.
4. Diffuse.

In the granular form we find abundant spawn-like bodies, traversed by blood-vessels. The swelling may be so great that the everted lid looks like a great tumor, whose surface is coated with these granules.

By papillary trachoma is meant that which is confined to the papillary region of the conjunctiva, and is described by Stellwag as an *ophthalmia granulosa* of a low degree of development: the tarsal conjunctiva is relaxed and strewn with fine proliferating papillæ.

Mixed trachoma, which is also termed inflammatory, catarrhal or blennorrhœal, is the most common form of trachoma.

The papillary excrescences are very marked, but they do not have the characteristic spawn-like appearance of pure trachoma.

Diffuse trachoma is described by Stellwag, as a higher grade of development than mixed trachoma. It is distinguished by the quantity of neoplastic formations in and upon the conjunctiva, as well as by the participation of the tarsal cartilage, the cornea, and the integument. There is great swelling of the palpebral conjunctiva. It is caused by immense granulations, separated from each other by deep fossæ. They are velvety in appearance and resemble a cock's comb, or broad condylomata.[1]

Treatment.—For a disease which exists in such great variety of severity in different cases, it is not easy to lay down a plan of treatment which shall be applicable to all cases. We may also distinguish, under a clinical classification, two general classes of trachoma; one is attended by intolerable photophobia and lachrymation, and by vascular keratitis (*pannus*, literally, a red cloth), or other forms of corneal, or even iritic disease. This is the most intractable. It usually occurs in debilitated or at least in badly nourished subjects. It is found in all grades of severity. In such a case as this, before the proper local treatment for the fundamental disease is undertaken, the enlarged follicles and the new formations demand a preparatory treatment. This can only be undertaken in a hospital, or if in a private house only where good personal attendance can be secured. The preparatory remedies to be used in such cases may be tabulated as follows:

1. *Hot Water.*—This should be applied as a fomentation, using absorbent cotton dipped in boiling water. It should be applied continuously to the eyes for twenty minutes, about six times a day.

2. *Sulphate* of *Atropia.*—An instillation of this should be made from three to six times a day, a solution of the strength of two grains to the ounce being employed. A solution of hydrobromate of scopolamine, one grain to the ounce, may be substituted for atropia, if desired.

3. *Hydrochlorate of Cocaine.*—This also, if on trial it subdue the photophobia, should be repeated, using considerable quanti-

[1] Stellwag: English translation, fourth edition, p. 404.

ties—ten to twenty drops, eight grains to the ounce, at a time—four to six times a day.

If under these means, in a few days, the photophobia and lachrymation lessen, we may begin to feel our way, in an astringent treatment. It will be best to begin with a tannic-acid spray, or with a crystal of alum, applied once or twice a day. Should the disease gradually yield under this treatment, as it often will, we may advance to the careful use of a crayon of sulphate of copper, once or twice a day, and in a few weeks from the beginning of the most obstinate cases, we shall see the granular masses disappear, the cornea clearing up, and improvement in the vision. When the cornea has become coated by blood-vessels or infiltrated with new formation, corneal astigmatism results. The ophthalmometer is very useful in measuring this, and may lead us to order glasses to correct it, when the trachoma is fully recovered from.

But there are cases where, in spite of the careful and judicious treatment long continued, the photophobia and lachrymation are not subdued, astringents are not tolerated, and the patient is both suffering and blind. For these cases we still have resources, but the patient, it is to be remembered, must as a preliminary to any of the following methods of treatment be placed in a hospital or in a similar place, favorable for the personal care of a nurse. Indications may momentarily occur when it is necessary to discontinue active treatment, at once, hence the necessity for this precaution. Among the means for the treatment of inveterate trachoma, I rank:

1. *Jequirity.*—This treatment has an interesting history. It was used by Brazilian Indians for granular conjunctivitis or a kindred trouble, and De Wecker, of Paris, introduced it into civilized ophthalmic practice. After much trial of the jequirity bean at the Manhattan Eye and Ear Hospital, we are very well satisfied with the results of the treatment. We have used it a great deal, especially Dr. Webster, Dr. Emerson, and myself, and we have had no cases of loss of the eye from damage to the cornea from its use, such as have been occasionally reported. The jequirity should first be converted into powder. The patient is placed under the care of an attendant, and powdered jequirity, say to the extent of a grain, is placed upon the palpe-

bral conjunctiva.[1] In most cases, reaction, consisting of pain in the lids, redness, and swelling appear. This is to be combated by iced cloths. A membranous deposit is usually found on the conjunctiva in about four hours. Then the further use of the drug is to be stopped. A membrane is apt to form as the result of the first application. In obstinate cases it is sometimes necessary to repeat the application once or twice, or even three or four times. When the stage of inflammation, the result of the use of the powder, is over, the cornea will be less vascular, the photophobia decreased, and the case in a condition to be finished by the use of astringents, especially by the sulphate of copper, when the treatment as described above, should be undertaken and carried on. Jequirity is only a means of converting intractable cases into those of a milder form, that will respond to the usual means of treatment, and it is to be reserved for cases that have resisted a fair trial of ordinary treatment. Jequirity can be safely used only under the precaution already stated, that the patient shall be under the personal observation of an attendant.

There are other methods of treating inveterate trachoma, which should be mentioned, although they may be considered as having been generally abandoned:

2. *Synectomy or Peritomy:* introduced by C. Bader, of London. This consists in cutting and dissecting up the conjunctiva, around the cornea, so as to fully remove the *limbus conjunctivæ.*

3. Inoculation with the secretion of purulent conjunctivitis (Piringer). Desperate as this latter-named remedy may seem to be, it was not unjustifiable in extreme cases, before we had jequirity. Jequirity accomplishes the same end with no risk of loss of the eye, while inoculation, under whatever precaution and care, may be followed by destruction of the cornea, just as many another purulent conjunctivitis.

The treatment by a strong solution of tannic acid and glycerin deserves especial mention, as a very efficacious one in many chronic and intractable cases. The solution, which may be from ten grains to the ounce up to saturation, is used twice

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[1] I formerly used jequirity in solution, but at the suggestion of Dr. Cheatham, of Louisville, we have used it in the Manhattan Eye and Ear Hospital exclusively as a powder.

a day, a drop in the conjunctival sac, while general care as to local cleanliness and lubrication is practised.

The less chronic form of trachoma, or rather the form uncomplicated by vascular cornea and changes in the tarsal cartilage, is usually very amenable to treatment, when it is continuous, judicious, and thorough. Such cases run into the more severe forms, from such neglect. Many of these patients are at work, earning their bread, and are unable to give themselves proper care. In orphan asylums and similar institutions in New York, a large proportion of such cases are found, not at all isolated from the few children with healthy eyes, in some instances receiving inadequate treatment, and in some none at all. It was the investigations of contagious ophthalmia in New York, instituted by Dr. Richard H. Derby, to whose aid nearly all of the oculists in New York, were called in making up the statistics, that have led to improved police regulations among the children of the institutions. From my own examinations made some five years ago, I am able to say that I found trachoma epidemic in two very large orphan asylums. The conditions are said to have improved somewhat, but much remains to be done to rid New York of a disease which annually destroys many eyes, and causes a great burden of taxation to the commonwealth.

Trachoma is so highly contagious, that all cases should be carefully quarantined from healthy eyes, and from each other as far as the use of the same appliances for washing, the sleeping-rooms, and so forth. Granular ophthalmia has decimated armies, and it is insidiously at work in many large and small cities, rendering the subjects of public charity unable to earn their living, and the carriers of disease.

It is an interesting and important fact, that inoculation with the various varieties of conjunctivitis does not produce the same disease. Catarrhal conjunctivitis may produce a blennorrhœa or even a pyorrhœa, while trachoma inoculation does not necessarily produce trachoma, but more likely a conjunctivitis, which if promptly treated never becomes trachoma. This fact must be explained. I think that the soil is different in different cases, and leads us to say again, that besides the germ for the production of suppuration or catarrh, we require a membrane ready to cause it to grow.

SURGICAL TREATMENT OF TRACHOMA.

Of late the surgical treatment of granulated lids, or trachoma, has assumed a new importance. Some of this may be due to the desire for something new, without thorough regard to the new thing being absolutely better than the old. Yet there are a few cases, but not in the opinion of the writer very many, in which the ordinary treatment, supplemented by the extraordinary, that is to say, the use of jequirity, fails within any reasonable time, or perhaps utterly, to cure the patient. Then it will be proper to resort to certain methods, that will now be detailed.

It is not true, however, as is sometimes intimated, that the treatment of a severe case of trachoma *necessarily* involves a period of time varying from a few months to years. Neither is it true that there is any considerable danger, in fact any danger, under proper precautions, of sloughing of the cornea from the use of jequirity. So that the practitioner should not start out with the idea, that the old methods of treatment have been, on the whole, valueless. There is no department of ophthalmic surgery presenting a much larger proportion of successful results, than the treatment of trachoma, judiciously chosen and thoroughly carried out. It is always to be understood, that a patient with trachoma, is to be informed at the start that a case which has already existed for years, will require months at least for a cure. It should not be forgotten moreover that trachoma, in a large majority of instances, is a disease that would not occur, or would be very easily managed, were it promptly treated, if the conditions which favor it, such as subacute conjunctivitis, bad habits of life, general unsanitary conditions, be removed. The surgical treatment of trachoma, is advocated chiefly for the first and second stages. The first method to be mentioned, is that employed for many years by Galezowsky (Paris), which consists of removal of the trachomatous bodies by excision. The patient should be put to sleep, the lid everted, and the male blade of Galezowsky's double-pointed toothed forceps carried into the cul-de-sac. The fornix is then thoroughly exposed and fixed by closing the forceps. All the folds of the fornix are then cut out with the scissors.

In cases where the trachomatous bodies extend to the ocular conjunctiva, the upper part of the tarsal conjunctiva and a part of the ocular are removed. The eye is then washed with a weak solution of bichloride of mercury or the like, 1 : 5,000. The eyes are then bandaged. The bandage is removed in a day or two and the eye treated with mild applications.

2d. Partial removal of the bodies by expression. This is employed considerably in the Manhattan Hospital in my clinic, by Dr. Frank N. Lewis, and by the other surgeons. It is also used in many of the New York institutions, and instruments have been invented for its proper manipulation by Noyes, Knapp, and Gruening. For this operation, the patient is also put under ether, the lids are everted, the loose rolls of the conjunctiva seized with the forceps, and stripped of the contents by a rather slow movement. This is continued until all the tracho-

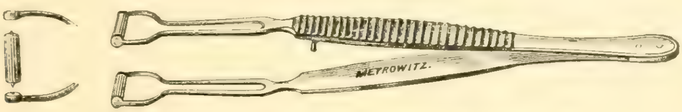

FIG. 130. –KNAPP'S ROLLER FORCEPS FOR EXPRESSION.

matous granules have disappeared. The conjunctiva is then washed with boric acid. The eyes are left open afterward. In a few days an astringent treatment is begun. The conjunctiva is very much congested for some time, but this congestion gradually disappears, and recovery with little remaining trachomatous tissue and little shrinking occurs. Some surgeons scarify the epithelial layer over the trachomatous granules: others rub in crystallized sulphate of copper after the operation. This method is applicable only to early cases where the granules have run under and become very hard. Where atrophy of the conjunctiva has appeared, it is of no use.

3d. Electrolysis has also been used for the destruction of trachomatous tissue, but this method has failed to secure any great following. Its employment necessitates rather expensive apparatus, which easily gets out of order, but more than all it is not an efficient method.

4th. In the same category with electrolysis, may be put the destruction of trachomatous granules by the use of the galvano-cautery. A sharp curette is also used by some surgeons.

5th. The removal of trachomatous tissue by brushing with a stiff brush (grattage). The patient is put under the influence of an anæsthetic and the trachomatous masses are brushed out with a tooth-brush having short and stiff bristles. This operation is extended by the introduction of a so-called germicide. This method of treatment was introduced in Abadie's clinic in Paris, and has been highly praised by Panas and De Wecker in Paris, Weeks,[1] Gruening, Noyes, Knapp, and others in New York. In this operation, after the lid is everted, the fornix fully exposed, and put on the stretch over the blades of the forceps, the conjunctiva is scarified by making incisions close to each other,

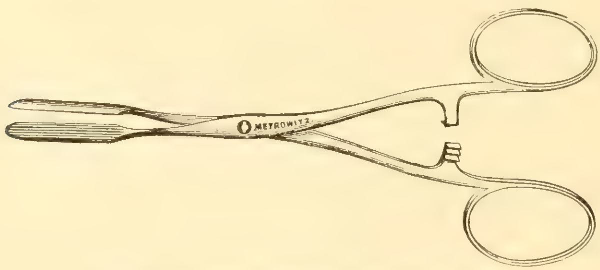

FIG. 131.—WEEKS' FORCEPS USED IN GRATTAGE.

and parallel to the margins of the lids. These incisions are united by transverse incisions. The incisions are made of a depth depending on that of the trachomatous tissue—they generally pass almost through it. Any trachomatous tissue that can be easily gotten out is pressed out by the back of the scalpel. The exposed surface is then thoroughly scraped with a tooth-brush, dipped in a solution of bichloride of mercury, 1 : 500. The eye is washed and bandaged with an antiseptic dressing. After twenty-four hours the bandage is removed, and the conjunctiva rubbed with absorbent cotton which has been dipped into a solution of bichloride of mercury, 1 : 500. This rubbing is repeated every day after the operation, for two weeks. If the reaction is very great, the applications are less frequent. Considerable œdema of the lids may follow this method. Those who advocate it, claim that the reaction is generally slight, and

[1] For an interesting paper on this subject see "The Surgical Treatment of Granular Lids," by John E. Weeks, M.D., New York Medical Journal, October 21st, 1891.

that the patient suffers very little, but the cases that I have seen do not lead me to commend this method. Some authors think this so-called "grattage" is just as efficacious, without the use of the bichloride of mercury. In a few cases symblepharon occurs, as a result of the operation.

At my request, Dr. Frank N. Lewis has given me a statement founded upon his large experience at the Manhattan Eye and Ear Hospital of his views as to the indications for expression. Dr. Lewis says: "The operation of expression or 'squeezing' is indicated in that kind of granular lids known as the follicular, where on everting the lids the palpebral surface presents the enlarged follicles with infiltration and thickening of the tissue. In some cases there may be only a few enlarged follicles and only in or near the cul-de-sac. In other cases the condition may be so magnified that the granulations form a large, irregular mass, covering the entire inner surface of the lid and even extending on to the eyeball. This latter somewhat resembles in appearance that condition of a granulating wound, popularly known as proud-flesh. The secretion is of a watery character, and the granulations are soft and contain a gelatinous substance. Expression is only to be used in the chronic and not in the acute form of granular lids."

PTERYGIUM.—XEROPTHALMIA.

(πτερυγιον, a little wing.)

Pterygium consists of hypertrophy of the conjunctiva and subconjunctival tissue, which forms a triangular-shaped, vascular prominence, generally at the nasal side of the eye, over the situation of the internal rectus muscle, with its base toward the inner canthus, and a rounded apex at the edge of the cornea, encroaching more or less upon the latter. It may also exist over the situation of the external rectus.

It is called pterygium *tenue* (Latin for thin), or *crassum*, (Latin for thick), according to its density. It is not a very common affection in cities, but it is quite frequently seen among sailors, those who live in the country in tropical climates, on the Western prairies, or in the Southwestern States of our country.

The etiology of pterygium is not certain, but those who have operated much upon this form of growth must have observed

that it seems to originate in an inflammatory condition at the very junction of the cornea with the ocular conjunctiva. This has led me to think that its origin is to be traced to a local inflammation, induced by a cutting wind, the presence of infinitesimally small foreign bodies, or similar causes.

Treatment.—It is not necessary to treat pterygium unless its growth is so considerable that it encroaches upon the cornea, and interferes with vision. It may also impair the motility of the eye, and, therefore, need removal on that account. The scar resulting from the removal of pterygium, is almost as disfiguring as the growth itself, and for this reason it is not worth while to excise it, unless as above stated. It is also to be remarked that it is very apt to return in persons living under the circumstances that have been above indicated. For this reason the operation should not be performed unless it produce the influence upon the sight or motility of the eye, which has been mentioned above. If it is decided to remove a pterygium the method which I advise is by excision.

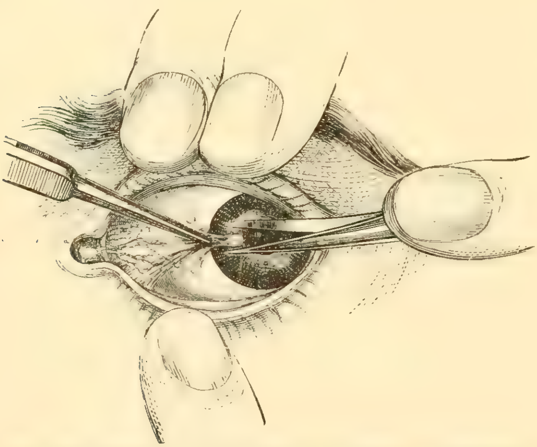

Fig. 132. Removal of Pterygium by Excision. (Stellwag.)

The growth is lifted up with the forceps, and thoroughly snipped away from the conjunctiva and cornea by a pair of delicate scissors or with a Beer's knife. Having been thoroughly dissected off, its apex is removed with the scissors or knife, the surface, with its grooves, gently scraped, and the wound united with two or three sutures.

Pterygium may also be removed by the method called transplanting. In this method, it is dissected off up to its base, and then inserted into an incision made in the conjunctiva parallel to the lower edge of the cornea. It is retained there by sutures. Pterygium may also be removed by ligature. A thread is passed

around the growth at two or more points, and tied so as to cause strangulation. In some instances, it may be preferable, when the growth has encroached upon the pupil, to make a new pupil by an iridectomy, opposite the clear part of the cornea.

The after-treatment is very simple. The patient should have his eye bandaged to go home, if the weather be bad, but if not, an ordinary shade suffices. The sutures, which should be of black silk, made aseptic before the operation, may be removed in from three to four or more days, as they seldom cause much irritation. The patient may use a mild astringent for a few days after the sutures have been removed, or there will be likely to be a moderate attack of conjunctivitis.

XEROPHTHALMIA, OR DRYNESS OF THE EYE.

(*ξηρος*, dry, and *οφθαλμος*, eye.)

This disease when it occurs, which is, fortunately, very rarely, usually results from severe chronic conjunctivitis. The pathology of the disease is atrophy and cicatricial change in the cornea, conjunctiva, and subconjunctival tissue, the surface being of dirty greenish or grayish color and tendinous appearance, and dry, scaly, and stiff from destruction of secreting apparatus. It produces obliteration of the palpebral folds, and more or less adhesion of the lids to the globe.

Treatment is useless, except to mitigate the affection. The dryness of the conjunctiva may be alleviated by a mild wash, such as milk or glycerin.

SYMBLEPHARON.

(*συν*, together, *βλεφαρον*, eyelid.)

This disease is an adhesion between the conjunctiva of the lids and the globe. It has already been alluded to in discussing injuries of the conjunctiva. It results from injuries causing excoriation and sloughing, or from long-continued inflammation. The adhesion may be complete or only partial, in form of small bands or bridles. It is very difficult of cure,—in many cases a cure is impossible. The best operation, where the case admits of one, is the use of conjunctival flaps. Attempts have been made to transplant conjunctiva from a rabbit, but the treatment is very

unsatisfactory because it is usually unsuccessful. The complete transplantation, grafting of mucous membrane, is now often substituted for the other operations. Mucous membrane may be taken from the mouth. It should be very much larger than the defect which is to be covered, and be without any submucous tissue. A great number of stitches have to be used to get it into good position. It is advised, in order to insure its applying itself throughout the whole wound, to put in one or two loop stitches at the fornix, which are brought through the substance of the lid, and tied at the outside. As in skin-grafting, the graft should not be positively fixed until all the bleeding has been arrested. It is, therefore, proper to begin with the stitches that attach it to the lid. The skin from the lower lid may be used instead of mucous membrane.

Snellen recommends an operation for bad cases, which consists in covering the inner raw surface of the lid, after it has been detached from the eye, with a flap of skin taken from the temple near the outer angle of the lids. After cutting the elongated flap, an opening is made below its base into the conjunctival sac. The skin is then pushed through this opening, so that its raw surface lies against that of the detached lid. It is maintained in this position by stitches. Berry[1] speaks well of this operation. Noyes, in New York, and others also perform it.

ANCHYLOBLEPHARON.

(*ἀγκυλωσις*, stiffening, and *βλεφαρον*, lid.)

This is an adhesion between the edges of the lids. It is from the same cause as symblepharon, and is sometimes associated with it. It requires the same kind of treatment.

[1] "Diseases of the Eye," by George A. Berry. Philadelphia, 1893, p. 665.

CHAPTER XVI.

INJURIES AND DISEASES OF THE CORNEA.

Injuries to the Cornea from Foreign Bodies.—Method of Removal.—Agnew's Method.—Primary Treatment of Injuries and Wounds of the Cornea.—Burns of the Cornea.—Scratch from the Finger-Nail.—General Treatment of Keratitis.—Phlyctenular Keratitis.—Vascular Keratitis (Pannus).—Suppurative Keratitis.—Inflammation of the Cornea.—Onyx.—Hypopyon.—Anterior Synechia.—Consequences of Keratitis.—Opacities.—Staphylomata.—Conical Cornea.—Fistula of the Cornea.—Tattooing of the Cornea.—Kerato-Globus.—Hydrophthalmia.—Buphthalmos.

Injury of the cornea always involves danger to the sight. As we have seen, the serious consequences of conjunctival disease are, that it may involve the cornea. In this chapter, primary and independent diseases of this tunic will be chiefly considered. It is hardly possible in actual practice, nor is it desirable, to separate those arising in the cornea itself, and those occurring secondarily from disease of the conjunctiva.

INJURIES OF THE CORNEA.

Foreign bodies, such as bits of steel, cinders, gun-caps, filings, beards of grain, gunpowder, sawdust, are some of the foreign bodies which may strike the cornea, and lodge in its tissue, without passing into the anterior chamber. If they lodge superficially, especially since the discovery of the anæsthetic properties of cocaine, they are not dangerous, and are readily removed, and very often with no trace of their presence, and no detriment to the sight. To remove a foreign body from the cornea, it should be first anæsthetized, by the instillation of a few drops of a four-grain solution of cocaine. Two or three instillations in as many moments are sufficient, if the body is not situated very deeply. A spud is the instrument to be employed. A good light is essential. Sometimes it will be neces-

sary to concentrate one from a double-convex lens upon the cornea, oblique illumination, but not usually. With the cornea anæsthetized by cocaine, an assistant may be dispensed with. If the foreign body be deeply situated, and frequent scrapings of the cornea about and under the foreign body, are necessary to remove it, it will be necessary to repeat the instillations, and continue the scraping until the substance is entirely gone. Then a needle must be substituted for the spud. If only the epithelium be involved, considerable scraping to remove the particles will be well tolerated, and the eye will quickly heal. In some cases, it may be necessary to keep the patient from his usual occupation, for twenty-four hours or more, after the removal of a foreign body from the cornea, but in superficially attached particles, even this precaution will not be necessary. In many machine-shops, there are expert workmen who readily remove these foreign bodies from the eyes of their fellow-workmen, with a knife-blade, a probe, or other instruments. Were they to add cocaine to their appliances, their skill would be greatly assisted.

FIG. 133.—SPUD.

FIG. 134.—NEEDLE.

When a foreign body is so deeply situated in the cornea, that there is danger by manipulation of getting it into the anterior chamber, it is necessary to proceed with much more caution. The patient should be placed upon a table, the eye anæsthetized, and with a very irritable patient general anæsthesia had better be employed. If the operator, after a careful trial with a needle and spud, cannot raise the foreign body from its bed, a magnet may be used. If this fails, as it will be apt to, on account of the embedding of the particle, it will be well to employ Agnew's method which will now be described.

FIG. 135.—GROOVED SPUD.

The eye is held open by a spring speculum, in the usual way, and fixed with a fixation forceps. A Beer's cataract knife is then passed through the cornea, so as to be behind the foreign body. The surgeon can then work upon it with needle or spud or forceps, until it is extracted without danger of the foreign body passing through the cornea into the anterior chamber.

TREATMENT OF INJURIES OF THE CORNEA.

The primary treatment of injuries and wound of the cornea is to put the eye at rest, and allay irritation by soothing applications. Atropine and cocaine should be applied several times daily, and iced cloths if the reaction be severe. Where the epithelium is abraded, a few drops of olive oil are useful to lubricate the parts and allay pain. The compress bandage may be used to restrain motion of the lids and to exclude light. It may be said, in a general way, that an injury of the cornea, not attended with great pain or watering of the eye, where the epithelium is simply scraped off, is usually best treated by the use of atropine or scopolamine, and a bandage. Beyond this the treatment must be adapted to the special requirements of the case.

Foreign bodies embedded deep in the cornea, have sometimes been removed by a corneal trephine (Agnew).

BURNS OF THE CORNEA.

Certain chemical agents or burns have serious influences upon the cornea, and however early they are seen after the occurrence, are apt to leave permanent opacities. A scratch from the finger-nail, such as is not infrequently inflicted by very young children or infants upon the cornea of their nurses or parents, is a painful and serious injury, which may be long in healing. A flannel bandage skilfully applied is often very useful by keeping the eye at rest. Such scratches do not often leave a permanent opacity, since they usually involve only the epithelium. Wounds of the cornea that penetrate entirely through its tissue, are dangerous, because with them occurs prolapse of the iris, which may result in its being fastened in the wound, *anterior synechia*, with all its permanent consequences to the eye. When the iris is once adherent, either to the cornea or to the capsule of the lens, the capacity of the eye for accommodation is impaired. It must always work under a disadvantage, at occupations requiring accommodative power. Injuries deeper than the epithelium and Bowman's membrane, involving the so-called "true structure" of the cornea, will usually leave a permanent opacity, even when they occur in very young children. We often find them very materially impairing the vision

in young men and young women, who were so young when they suffered the injury causing the ulceration, that they do not remember it. Sometimes the opacities can only be seen by oblique illumination. There are also facets transparent that alter the curvature of the cornea, and produce irregular astigmatism, but these facets impair vision almost as much as opacities.

KERATITIS.

(κερας, horn.)

1. Diffuse keratitis, or interstitial or parenchymatous keratitis.
2. Circumscribed keratitis—ulcers, abscesses.
3. Vascular keratitis.
4. Bullæ of the cornea.
5. Phlyctenular keratitis.

Diffuse keratitis presents a great variety in appearance and origin. The clinical picture shows a general haziness of the entire surface. This haziness is due to cell proliferation in the deeper layers of the cornea. It usually extends from the margin to the centre of the cornea, rarely from the centre to the margin. It varies in degree from slight haziness to a dense opacity, like that of ground glass. It is generally of a grayish color, and may be thicker in some parts than others, and thus produce white or yellowish patches.

From the loss of epithelium, the surface also may lose its polish, and assume a dull, stippled appearance. Blood-vessels sometimes appear in the margin and run toward the centre. They may in some cases be so numerous as to produce a bright red color, like that from extravasated blood.

When connected with other symptoms, diffuse keratitis gives undoubted evidence of inherited syphilis. The other symptoms are want of development of the upper jaw, impairment of hearing, nodes upon the tibiæ, glandular swellings, and a peculiar notching of the teeth. It is not necessary to have all of these with the cloudy cornea, to mark the disease. Some of them may be absent, but Hutchinson's notched teeth once present, with the keratitis, and we may be sure that we are dealing with a case of congenital syphilis.[1] Accompanying the

[1] The profession is indebted to Jonathan Hutchinson, of London, for an exhaustive monograph upon this subject of congenital syphilis, with especial refer-

diffuse opacity, or ground-glass appearance of the cornea, is the zone of ciliary redness, watery eyes, and photophobia, which exist in greater or less degree, according to the activity of the case. The origin of such cases, as has been said, is to be found in a syphilitic taint in one or both parents. It is often very difficult to procure positive evidence upon this point, but the appearance of these symptoms in a pronounced way is sufficient proof, with no appearances in either parent that positively point to the presence of syphilis.

It is thought by some that this form of circumscribed keratitis (Callan, New York) occurs even in the course of acquired syphilis, as well as in hereditary. If this be so, it is at least a rare occurrence. Acquired syphilis rarely if ever, invades the cornea. This is a remarkable clinical fact, for, while we have a large proportion of cases of iritis, due to acquired syphilis, as well as retinitis, choroiditis, hyalitis, and even scleritis, we may safely say, that an adult subject suffering from primary syphilis scarcely ever presents the characteristic signs of diffuse keratitis, which are so marked as one of the evidences of congenital disease of the same character.

Treatment.—This should be in the first place hygienic, and then anti-syphilitic, by mercurial inunctions, using the oleate of mercury, and by the iodide of potassium internally. Great care should be taken in the administration of the latter drug, that is, not to give over-doses, and to give it well diluted, so that its use may be maintained for a very long time. The mercurial treatment is, however, more important in congenital syphilis than that by the iodide of potassium, that is to say, it is much more likely in ordinary treatment that the mercurial be not quite long enough, while the iodide of potassium is pushed too far. Great stress should, therefore, be laid upon the long-continued use of mercurial inunctions. They may be continued for months.

Tonics and nutrients, such as cod-liver oil and iron, are also generally indicated. The patient should be much in the open air if possible, and in every way means taken to maintain the best possible general condition. An inflammation of the cornea,

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ence to the facial signs,—want of development of the upper jaw, notched and badly shaped teeth, which is still well worthy of the attention of the reader. "A Clinical Memoir," Churchill, London, 1863.

which is not traumatic in origin, always indicates that there is something wrong in the general health. The method of its healing, its rapidity, and so forth, will furnish an index of the nutrition of the patient. By this I mean merely to say, that keratitis is a disease of poorly nourished people, and the non-healing of a corneal wound indicates a somewhat lowered state of the general health. Locally, atropine and cocaine are to be used, and when the photophobia and lachrymation are marked, fomentations should be made with hot water, by dipping absorbent cotton into boiling water, and applying it to the eyes, very frequently during the day. The patient should wear a veil, broad-brimmed hat, or colored glasses, or similar protection, when in the open air. Pains should be taken that children, suffering from this disease, should not bury their heads in the pillows, or keep away from the light constantly, as they are very much inclined to do, on account of the photophobia. One of the great objects of treatment in the beginning of a case is to alleviate this very painful symptom.

Prognosis.—In spite of the very discouraging appearances of cases of diffuse keratitis dependent upon congenital syphilis, in their onset, and the fact that the sight may be impaired at an early period so that only quantitative perception remains, the prognosis, in persons who can be put under proper hygienic conditions, is usually good. While a person attacked in the ears by the poison of congenital disease, rarely recovers his hearing, on the contrary where the eyes are inflamed the sight is usually regained, at least to a very comfortable degree, involving the ability to read and sew and the like. Having once made a diagnosis, and with the means of securing proper care for the patient, we may usually hold out the hope of a clearing up even of very cloudy corneæ, and consequent restoration of sight.

It is thought by some, that the treatment by tonics and nutrients is all that is necessary, that the mercury and potash may be omitted, but having had excellent results in nearly all my cases with a strict and long-continued anti-syphilitic treatment, I should be unwilling to abandon it. There will, however, be often intervals in the management of such cases, when the use of the specifics should be suspended, and only general hy-

gienic care be prescribed. I have had under occasional observation, for twenty years, a woman, now about forty years of age, who in spite of several relapses from diffuse keratitis still retains good sight and not particularly sensitive eyes. During all this period she has been a school-teacher. On the other hand I have seen cases, happily exceptional, where complete loss of sight has been the permanent result of tolerably thoroughly conducted treatment. They are always cases in which the general nutrition was hopelessly impaired. I believe with Jonathan Hutchinson, that mercury is an antidote to syphilis, quite as much as quinine is one for malarial poisoning.

Diffuse keratitis of a local origin, should be treated in the same manner as that dependent upon congenital syphilis, except that the specifics may be omitted. The bichloride of mercury will, however, be found to be a good tonic in many cases of keratitis.

SUPPURATIVE KERATITIS.

In this form, inflammatory infiltration becomes changed into pus, which appears as a yellow opacity in the corneal tissue. The suppuration may be limited, or the entire cornea may be changed into a yellow, necrosed mass. If a suppuration is enclosed by corneal tissue, it forms an abscess, if superficial, an ulcer. Sometimes the pus sinks down between the layers to the lower margin of the cornea, presenting the appearance called onyx (ὄνυξ, nail) or *unguis* (Latin for nail), from resemblance to the *lunula* of the finger-nail. If pus breaks through into the anterior chamber, it forms hypopyon. By oblique illumination, and looking at the cornea in profile, it is generally easy to distinguish between onyx and hypopyon. Sometimes they coexist, as shown in the cut above. The suppurative process may be attended with vascularity and very active symptoms, or there may be no vessels and little or no irritation. The latter form is specially dangerous from rapid death and sloughing of

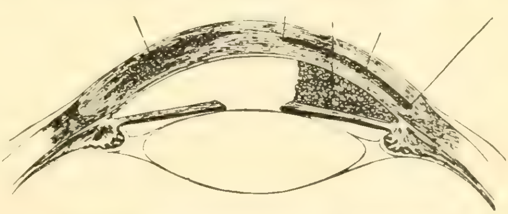

FIG. 136.—HYPOPYON AND ONYX. (STELLWAG.)

the tissue. Abscesses may be absorbed or burst open, or pus may undergo fatty or chalky degeneration, leaving a dense opacity. When the abscess opens an ulcer results. Ulcers also occur superficially, without precedent abscess. They are of variable size, shape, and depth, and dangerous according to their situation and course. A very dangerous form is the crescentic marginal ulcer, which shows a tendency to encircle the cornea and cut off the nutrition of the central parts. In small ulcers extending to Descemet's membrane, the latter may bulge forward through the ulcer like a vesicle, forming keratocele, or hernia of the cornea. Perforation generally follows. Larger ulcers frequently lead to staphyloma. If an ulcer goes on to perforation, there is a sudden escape of the aqueous humor, which is apt to carry the iris forward into the wound, where it may become firmly adherent during the healing of the ulcer, forming what is called anterior synechia (σύν, together, and ἔχω, to hold). If the perforation is large the iris may protrude through it, and become adherent around its edges, leaving staphyloma. Sometimes after the healing of the ulcer, reaccumulation of the aqueous humor and action of the pupillary muscles are sufficient to tear loose the adhesions of the iris, and allow it to fall back into its proper place. The lens may also be carried forward with the iris against the perforation, and when it returns to its position, it is apt to carry with it some inflammatory deposit on its anterior capsule, forming anterior capsular cataract. The adhesion of the iris and lens to the posterior surface of the cornea, may be so extensive and firm that an anterior chamber is never re-established. When sloughing of the cornea is very extensive or total, escape of the lens and vitreous, and atrophy of globe may result. Small ulcers may be filled up by transparent tissue and heal, without leaving a trace. Slight superficial

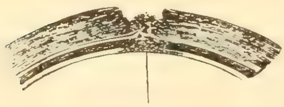

FIG. 137.—DEEP ULCER. (STELLWAG.)

FIG. 138.—ULCER AND PROLAPSED IRIS. (STELLWAG.)

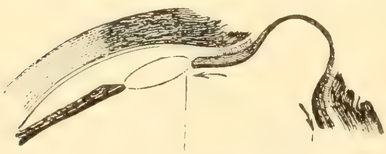

FIG. 139.—COMPLETE STAPHYLOMA OF IRIS.

cloudiness may remain, which gradually clears up, or a permanent white, tendinous cicatrix may be left. During the healing process vessels appear running over the cornea to the ulcer.

Causes.—Suppurative inflammation may result from the same causes as other forms. It is a dreaded result of operations involving corneal incision, especially in the old and feeble (see cataract). Bruised and lacerated wounds are apt to cause it. It is also one of the dangers of purulent conjunctivitis. It occurs in paralysis of the fifth pair, as neuro-paralytic ophthalmia. Such a paralysis renders the cornea anæsthetic, hence insensible to the action of external irritants, and seems also to exercise a bad influence upon its nutrition.

Treatment.—This includes ordinary remedies for keratitis. Special cases call for special means. It is not customary to evacuate pus except in hypopyon, and not always here. Even a large hypopyon is often re-absorbed. It is often essential to keep the intra-ocular pressure reduced. This is done by the operations of paracentesis or iridectomy. Paracentesis may be repeated frequently. When great pain occurs in conjunction with suppurative keratitis, even without very marked increase of tension, it is important to perform a paracentesis, but if the suppuration goes on without pain, and without increased tension, it is often advisable to avoid opening the cornea. Cauterizations with pure carbolic acid, or the actual cautery, are sometimes efficient.

PHLYCTENULAR KERATITIS.

The description of this disease, has already been given in the chapter upon phlyctenular conjunctivitis. It only differs from that affection, by the appearance of a pustule or phlyctenule upon the cornea. Of course, at the same time there may be phlyctenules upon the conjunctiva. Fortunately the nodules occur chiefly at the margin of the cornea. They appear as inflammatory nodules, singly or in groups. They may be surmounted by vesicles, which burst and leave small ulcers, or ulcers may result from loss of tissue in the nodule without the intermediate formation of a vesicle. When the eruption is limited, the attendant congestion is partial, a triangular network of vessels is seen running toward the phlyctenule, its base toward the retro-tarsal fold and its apex at the phlyctenule, if this is at the

edge of the cornea. If the phlyctenule lie some distance from the edge of the cornea, the apex of the triangle appears cut off at the latter—a space of clear tissue intervening between it and the phlyctenule. If the disease is severe, vascular keratitis may supervene, the vessels extending upon the cornea quite up to the phlyctenule. The pain and photophobia are generally marked, the latter symptom sometimes being out of all proportion to the amount of inflammation.

The secretions from the eye, are very irritating to the skin upon which they flow. They soon act upon the epidermis and cause superficial ulcerations; nasal catarrh is always an accompaniment of the typical forms of the disease. In fact, phlyctenular keratitis, is but the same form of conjunctivitis extending upon the cornea. It is possible that some, if not many, cases originate in the nasal mucous membrane, and that the rubbing of the hyperæmic conjunctiva with the secretion from the nostrils, is the first cause of the phlyctenule. There are phlyctenular inflammations, however, without nasal catarrh. The disease may arise from direct irritation of the ciliary nerves, or be extended to them from the fifth pair. It is unnecessary to go again into the subject of the treatment of phlyctenular disease. The reader will find that fully considered under the head of phlyctenular conjunctivitis. The only deviation from the treatment in the former case is, that atropia is more urgently indicated in keratitis than in conjunctivitis. It has been objected to the use of atropia in mild forms of keratitis, that it dilates the pupil, and exposes the eye unnecessarily to light, but I think this is a purely theoretical objection. As a matter of fact, the eye is always shaded from very strong light, and the benefit from the release of the action of the ciliary muscle is very considerable. Superficial ulcers may be sometimes treated by scraping them.

VASCULAR KERATITIS (PANNUS).

This disease is characterized by superficial infiltration, and grayish cloudiness of the cornea, with a network or a solid mass of vessels traversing the affected region.

The epithelium may be removed in the course of the disease, and cause superficial ulceration and great pain. The pain is due to exposure of the nerves.

This disease is the pannus of older writers. It is usually a consequence of trachoma, but it may occur spontaneously, or in conjunction with diffuse and phlyctenular keratitis. The covering of the cornea by blood-vessels is a reparative process, or rather a protective one to guard the cornea from ulceration in the course of granular conjunctivitis. In such cases attention to the primary disease soon causes the vessels to shrivel and disappear. But as an independent affection as it sometimes is, or occurring in the course of diffuse keratitis, it is much more obstinate to treatment.

PANNUS (*pannus*, a cloth) is, strictly speaking, a non-inflammatory, superficial, vascular opacity of the cornea—a neoplastic formation left by preceding inflammation. The term, however, is also applied to acute and chronic vascular keratitis, when formation of new tissue is still in progress. The disease may involve a part or all of the cornea. The mild form is called *pannus tenuis*, the severe one *pannus crassus*. In extreme degrees, the cornea may have a red, fleshy appearance. The disease may continue for months or years without marked change. A complete cure may occur, but it is rare. As a rule, opacities are left, and sometimes the cornea is completely covered by a thick, dry, tendinous-looking membrane. It may become thinned and bulged forward. The most frequent cause of pannus is trachoma, and the corneal surface may then present granulations like those on lids. It may be traumatic from long-continued irritation, such as that from foreign bodies, inverted cilia, exposure to the atmosphere, and so forth. The treatment aims, after removing the cause, to hasten resolution of the opacity. For this, irritant powders and ointments are used if no inflammation exists. Sometimes remedies lose their effect and must be changed or intermitted.

Treatment.—The local treatment of all forms of keratitis involves the use of hot fomentations, atropia, and cocaine according to circumstances. What has been said on this subject as applicable to other forms applies here as well.

CONSEQUENCES OF KERATITIS.

Opacities of the cornea, corneal leucoma (λευκος, white), staphylomata, conical cornea, fistula of cornea.

Opacities are a frequent result of corneal inflammations with cicatricial deposit. They are divided into superficial and deep, the former affecting the epithelial layer, the latter the parenchyma. A faint, superficial opacity is called *nebula* (Latin for fog); a thick, dense one, *leucoma*, literally a white tumor. A cicatrix combined with prolapse and adhesion of the iris is called *leucoma adherens*. White, chalky-looking incrustations may result from metallic deposit, as where a lead lotion has been applied to an ulcerated cornea. Opacities impair the vision according to the alteration of curvature accompanying them, and may necessitate constant straining for vision of small objects, leading to artificial myopia and to strabismus. If they prevent distinct retinal impressions, the eye may become amblyopic from disuse (?) and deviate outward. In children these may cause nystagmus. Many opacities disappear spontaneously, especially in young, healthy subjects. As a rule, the more recent and superficial the opacity the better the chance of its removal. Irritants such as calomel are used to assist absorption by exciting hyperæmia and increased tissue change. Lead deposits are sometimes scraped off with a knife in the hope that the resulting ulcer will be filled up with transparent tissue. Where opacities are central, resist all treatment, and obstruct the vision, one of the operations for artificial pupil may be performed. The new pupil should be made opposite that part of the cornea that is most transparent, and of most correct curvature. Where the small part of the clear cornea remains over the pupil, the vision may often be improved by stenopœic spectacles (στενός, narrow, and ὀπή, hole), which cut off lateral and diffused rays of light. They are made of metal or ground-glass plates with a small central slit or hole. They contract the visual field greatly, and can be used only for close work. Unsightly white opacities which cannot be removed are sometimes tattooed with India ink for a cosmetic effect. Diffuse cloudiness of the cornea, sometimes results from derangement of corneal elements by increased intra-ocular pressure. In certain diseases, such as serous iritis, irido-choroiditis, and so forth, fine punctate opacities are deposited on the posterior surface of the cornea (*aquo-capsulitis*).

DISEASES OF THE ANTERIOR CHAMBER.

The affections of the anterior chamber, like those of the vitreous humor, are hardly to be considered as independent affections. Yet they deserve an especial consideration by themselves. Pus in the anterior chamber (hypopyon) is a not infrequent and serious occurrence in certain cases of keratitis, and also in iritis. Sometimes it is seen only as a fine grayish-white line, when the patient is lying down, so that the pus falls to the lower part of the chamber, but usually it is a well-marked quantity of pus in the chamber. It may be absorbed if the quantity be not large, and the disease of the cornea or iris upon which it depends come under control. If the quantity, however, be large, and the corneal inflammation or that of the iris, be not abating, a paracentesis of the cornea is a valuable resource, not only as a means of evacuating the chamber of much of the lymph and pus, but also of improving the nutrition of the eyeball, as a paracentesis often will. Besides it is a means of getting a more thorough action of atropia, when the cornea does not readily take up the drug, that is applicable in certain cases of keratitis and iritis, when no hypopyon is present.

Hypæmia in the Anterior Chamber.—As a result of injury of the eyeball and hemorrhage from the anterior ciliary vessels, blood may escape into the anterior chamber. If the other injuries are not serious, the blood may be absorbed and the eye be restored. Where, however, hemorrhages occur from the iris, which has become degenerated from long-standing disease, one hemorrhage follows another, the vitreous humor becomes full, the eyeball tense, frightful pain ensues, and the eye must be enucleated to give relief to the patient.

Hemorrhage into the Anterior Chamber, may occur in the course of operations for chronic glaucoma. Sometimes the blood comes from the conjunctiva, when it is readily absorbed. The operator need not be too punctilious about securing its removal. If from the iris after it has been cut, the prognosis is of course not entirely good, although this blood also may be absorbed. When the bleeding is from the ciliary vessels, the prognosis is naturally bad for the safety of the eye. Once

having occurred, it continues to occur and finally destroys the eye, by pressure upon the choroid, retina, and nerve.

CICATRICIAL STAPHYLOMATA.

(σταφυλη, bunch of grapes.)

This is generally the result of ulcerative keratitis. The floor of the corneal ulcer, is very apt to yield and bulge forward from intra-ocular pressure. During the healing process, the bulging part is covered over with cicatricial tissue, and a bluish-white protrusion, or *staphyloma*, is left. To this the iris may be partially adherent posteriorly. Or if perforation occur, the iris

FIG. 140.—VARIOUS FORMS OF CORNEAL STAPHYLOMATA. (STELLWAG.)

may prolapse, close the wound, protrude through it, and form a basis for the cicatricial deposit. Staphyloma may be partial or total. In the latter case it involves the whole cornea. If partial the tendency is to increase. The lens may retain its position, or fall forward and press against the posterior surface of protrusion. The walls of the staphyloma may be very thin, and may burst, or may gradually thicken with fresh inflammatory deposit. Repeated attacks of inflammation and ciliary irritation may occur, and finally lead to sympathetic ophthalmia, especially where the iris is involved and in a state of constant tension. Staphyloma sometimes results from wounds of the cornea and rarely from cataract operations.

Treatment.—In partial staphyloma, treatment aims to prevent further progress, to reduce the protrusion already existing, and to improve the vision. Repeated paracentesis with methodical use of a pressure bandage, or iridectomy followed by pressure, may succeed. In very extensive or total staphyloma, splitting or incision may be performed, the lens being also removed. Splitting is done by passing the knife through the long diameter of the tumor, and allowing the edges to fall together and unite with a view to producing a flatter cicatrix. Quite a piece of the edges of the wounds should be cut off. Excision is performed by cutting the tumor off at its base, and allowing the edges of the wound to collapse and cicatrize. Critchett's operation (Critchett, London, Nineteenth Century) consists in passing several curved needles armed with silk through the base of the tumor and cutting the latter off just in front of them. The needles are then drawn through, and sutures tied so as to unite the edges of the wound and form a flat stump for an artificial eye. This operation, if the needles go through the ciliary region, is dangerous from risk of sympathetic ophthalmia. Enucleation is often preferable.

CONICAL CORNEA.

KERATO-CONUS is a cone-shaped staphylomatous protrusion of the cornea, whose cause is not well understood. The cornea is thinned and less resistant, but the intra-ocular pressure is generally not increased, and is sometimes below normal. The affection comes on, as a rule, very slowly, and without pain or irritation, but with asthenopia. It occurs only in persons of delicate constitution. The cornea may become so thin as to move under the examination with the ophthalmometer. In such a case, that has been under my observation and that of Dr. J. B. Emerson for twelve years, the corneal astigmatism has developed as follows: In 1879, the vision was $\frac{20}{70}$, made $\frac{20}{20}$ with a positive glass of forty-eight inches focal distance. Four years after, a cylindric glass of $+\frac{1}{60}$ was required, and ten years after the first examination, a cylindric glass of seven diopters on one side, and of four on the other.

If conical cornea increases greatly, the apex becomes extremely thin, and is apt to become very much clouded, but it

never bursts, except from violence. The first thing noticed by the patient, is impairment of the vision, as the eye becomes myopic from the lengthening of the axis, and astigmatic, from irregular curvature of the cornea. In high degrees irregular astigmatism causes great distortion and reduplication of images. Slight grades are often overlooked; but high degrees may be easily seen, especially in profile. If the eye is illuminated by the ophthalmoscope, a central red reflex is seen surrounded by a dark ring, outside of which is a second, bright-red ring. By throwing the light from different angles, the side of the cone opposite the light is seen in shadow. If the fundus is examined, everything is seen distorted. The ophthalmometer is the best means of confirming the diagnosis of low degrees of conical cornea.

Treatment.—The treatment is unsatisfactory. There is little improvement of vision from glasses. The stenopæic slit is occasionally of use. All straining of the eyes must be avoided. Operative treatment comprises iridectomy, iridodesis, trephining, and Graefe's operation, which consists in removing a superficial flap from the apex of the cone and cauterizing the part a few times with nitrate of silver, so as to produce a shrinking cicatrix and so flatten the protrusion.

KERATO-GLOBUS.—HYDROPHTHALMIA.—BUPHTHALMOS.

(*βους*, an ox, and *ὀφθάλμος*, eye.)

This is a uniform spherical bulging of the entire cornea, and neighboring part of the sclerotic. It is generally associated

Fig. 141.

Fig. 142.

Total Staphylomata. (Stellwag.)

with increased size of the anterior chamber and a tremulous iris and lens. The condition is usually congenital. It may appear after inflammation. The cornea may remain transparent or become cloudy, especially at the margin. It causes great

impairment of the vision, changes in deeper tissues, and often ultimate blindness. Treatment is of little use. Iridectomy may be of service in a few cases.

The cut on the preceding page, from Stellwag's treatise, gives a graphic and correct idea of total staphyloma (Fig. 142), with complete destruction of the corneal tissue, and general staphyloma, with iritis, and closure of the pupil.

FISTULA OF THE CORNEA.

This may result from a wound or small perforating ulcer, and is very difficult of cure. The aqueous humor continually drains away, and the eye is kept irritated. Treatment comprises atropine, touching the fistula with nitrate of silver, bruising its edges with fine forceps to excite healing, compress bandage, iridectomy, and so forth. When there is so much disease as to excite sympathetic irritation of the fellow-eye, a sightless and staphylomatous one should be removed without hesitation or delay. An unsightly staphylomatous eye may also be removed for cosmetic reasons alone. Such an operation is entirely justifiable. For in spite of good care, such eyes are apt to be ultimately lost. Since they bear exposure to air or light very badly, a destructive inflammation may occur at any time. The nature of the condition, an anterior synechia always existing, explains this.

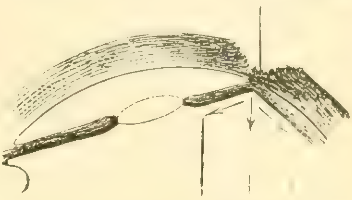

FIG. 143.—FISTULA OF THE CORNEA. (STELLWAG.)

The destructive keratitis figured in the cut, exhibits the origin of fistula of the cornea.

CHAPTER XVII.

DISEASES AND INJURIES OF THE SCLERA AND THE IRIS.

Wounds of the Sclera.—Episcleritis.—Scleral Staphyloma.—Wounds of the Iris. —Iritis—Prognosis.—Varieties.—Treatment.—Cysts and Tumors of the Iris.

THE injuries of the sclera are dangerous if perforating, and especially dangerous, in proportion to their nearness to the ciliary region. If perforating, they involve damage to the choroid, retina, and vitreous humor, and are more or less harmful to vision, but they do not necessarily, although they may possibly, produce sympathetic ophthalmia. But an injury of the sclera close to the ciliary body, or running into it, is of necessity always a menace not only to that eye, but also to the safety of the fellow-eye. Clean-cut wounds of the sclera should be united by sutures (Pomeroy), foreign bodies are to be removed, and the patient warned that the removal of the foreign body, if it have passed through the sclera into the choroid, or retina, or into the vitreous, does not preclude the occurrence of sympathetic irido-choroiditis, no matter how quickly the body may be removed, nor with whatever skill, or even if with little damage to the integrity of the tissue.

EPISCLERITIS—CHOROIDITIS PARTIALIS (Sichel).

This disease is characterized by a dusky red swelling on the sclera, near the edge of the cornea, oftenest on the temporal side.

Episcleritis may simulate a phlyctenule, but close observation will at once show that it is a deeper and more diffuse redness than that characterizing the latter-named condition. This swelling never shows any tendency to ulcerate or suppurate. In most cases there is ciliary irritation and redness. In cases of any long continuance, a diffuse circumscribed opacity of the cornea occurs, as well as inflammation of the iris and choroid.

It is very doubtful if the name *episcleritis*, *upon the sclera*, is usually comprehensive enough, for the disease is by no means a superficial one. It is generally an obstinate affection. It resists sometimes treatment for months, but again it yields quickly. It is connected with syphilis in a certain proportion of cases, but not a large one. I have seen many cases in rather delicate young women of good character, who gave no evidence of any kind of acquired or constitutional syphilis. It occurs also in the rheumatic diathesis. If it do not involve the cornea, iris, or choroid, it may be entirely recovered from without damage to the eye.

Treatment.—Locally: Calomel insufflations are usually of service, together with the dropping in of atropia solutions. Constitutionally: Iodide of potassium is a valuable remedy, often efficacious. But the iodide often fails to be of service, when pilocarpine injections should be tried. The latter should be given early in the evening, the patient being in bed; the dose to begin with is five minims of a two-per-cent solution, which should be increased until free perspiration is induced, after each injection. This treatment may be safely maintained for fourteen to twenty days, if it do not interfere with the general health of the patient. Then after an interim of a week or more, if the disease has not fully yielded to the treatment, it should be repeated.

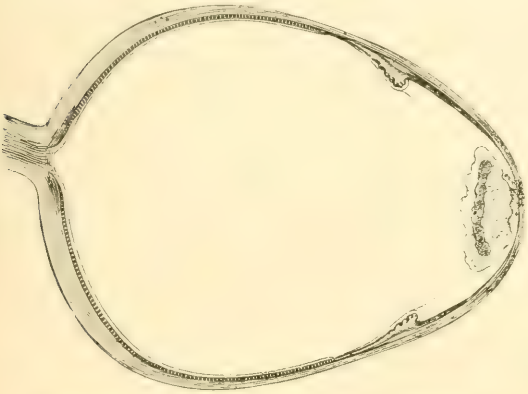

FIG. 144. TOTAL SCLERAL STAPHYLOMA. (STELLWAG.)

Besides the use of pilocarpine and iodide of potassium internally, both of which in some cases act very beneficially, I have found small doses of calomel, one-tenth of a grain, given four times a day, exceedingly valuable in certain cases that have resisted the medication which I usually adopt in the beginning, that is to say, the internal use of the agents first named. One patient, whom I have lately treated, who had syphilis, bore the

calomel for a number of weeks, and never showed any signs of mercurial poisoning, while the eye gradually cleared up.

What Arlt calls staphyloma of the ciliary body,[1] is a characteristic result of episcleritis. It is a protrusion in the anterior zone, corresponding to the situation of the ciliary body. The sclera has gradually become gray in color, and at the same time it protrudes, which causes a pushing forward of the base of the cornea. The staphylomatous swelling, which is quite abrupt at the corneal margin, is gradually flattened out toward the *ora serrata.*

STAPHYLOMA OF THE SCLERA.

This condition is most serious, for it involves the integrity of the eye. It is a result of disease which softens the tissues. The disease may begin in any part of the eye. It occurs as a result of keratitis following purulent conjunctivitis, or from long-continued irido-choroiditis. It may be anterior, involving the front of the eye from the cornea to the equator, or posterior, from the equator to the optic nerve. A scleral staphyloma may also involve the whole eyeball. It is not usually a disease to be interfered with by operation. In many cases of total staphyloma, the globe is so large that the lids cannot be closed over them, and causes very great deformity, as well as inconvenience to the patient. When there is an increase of tension, there may be danger of sympathetic trouble, when the eyeball should be removed by enucleation. Although this has been an accepted opinion, I am doubtful if sympathetic inflammation ever arises from a staphyloma of the sclera, not produced by ciliary injury.

INJURIES OF THE IRIS.

Wounds of the iris may heal readily, and if they do not involve the ciliary region, they are not necessarily productive of severe inflammation, nor of sympathetic irido-choroiditis. Blows may rupture the iris at its circumference and cause separation of it, *irido-dialysis;* or it may be prolapsed by a wound and emerge from the eye. Wounds of the iris, during cataract operations, are fully treated of in the appropriate chapter. It is usually better to cut off the prolapsed iris resulting from an

[1] "Krankheiten des Auges," 1881, p. 207.

injury, if the case be seen in a few hours,—yet it may be sometimes replaced and sulphate of eserine, gr. ¼ to the ℥ i., employed to keep it in position. Eserine is a drug that easily sets up iritic inflammation; it is, therefore, to be used with caution; its effects should be watched after each application. After the prolapsed iris is cut off, atropine should be used, gr. ij. to the ℥ i., and a flannel bandage applied. It is sometimes proper to treat a prolapsed iris by punctures with a needle, in order to induce sufficient flattening to cause it to cease to be a source of irritation.

IRITIS—INFLAMMATION OF THE UVEAL TRACT.

This is one of the frequently occurring diseases of the eye. It is one that is easily overlooked in its early stages by practitioners who do not see much of ophthalmic diseases. The consequences of a mistake in diagnosis are serious. Iritis is most frequently mistaken for conjunctivitis.

CHARACTERISTICS.—*Iritis is characterized by injection of the ciliary vessels, by a loss in brilliancy of the color, by more or less rigidity of the pupil, lachrymation and photophobia, and subjectively by pain, usually of a severe and neuralgic character, and by impairment of vision.*

If all these symptoms were present in every case, it would be a stupid observer indeed, who once having noted them, or who had even heard them once fully described, did not recognize the disease, when a case was presented to him. But unfortunately, iritis is not always plainly marked out by the presence of all these symptoms. The ciliary redness may be present, but the loss of color of the iris may be slight, pain may be nearly wanting, the vision may not be markedly impaired—although watering to a slight degree at least, with photophobia, is present in nearly all cases—and we may yet have iritis, and iritis of a dangerous form. The immobility of the iris is sometimes masked, so that we are not aware that it has suffered until a mydriatic is used, and we find it very sluggish. If a patient with suspected iritis, come to the practitioner who has no very large experience with diseases of the eye, he should examine the case very carefully with a magnifying glass, and he should question him as to whether there is any

gluing together of the lids in the morning. It is a fact, that even in cases of iritis of considerable severity, the secretions are so thin and watery, that the lids are not found glued together after sleep, while in the mildest forms of conjunctivitis they are. If, after all, the observer cannot definitely decide whether his patient has or has not iritis, he should apply a solution of atropia or scopolamine. If the iris dilate promptly in twenty minutes, well out to the margin, he may know that he has no iritis. If, however, it dilate very sluggishly, or if, what is of course crucial evidence, the slightest irregularity of its pupillary border appear, there is a synechia, and the existence of iritis is demonstrated. Happily, the diagnosis is usually easily made by a careful observer. Inflammation of the uveal tract is the name to be preferred to iritis, on many accounts, but so firmly in the term iritis fixed in the professional mind, that I do not deem it well to insist on the more correct nomenclature. The whole uveal tract is apt to be, if it be not always, involved in the inflammation of the iris. Certainly the ciliary region is, and generally the choroid.

Causes.—The causes of iritis may be divided into local and constitutional, or idiopathic and traumatic. Among local causes, wounds, either accidental or from operations, play a large part. This will be sufficently discussed in the chapters on Cataract.

Of the constitutional causes, syphilis is very prominent. A large percentage of cases of iritis are of syphilitic origin. It is of itself a suspicious circumstance, when a patient presents himself suffering from iritis. Yet we should not assume without evidence that an iritis is syphilitic, for a certain percentage occurs of non-syphilitic origin. Iritis is one of the early manifestations of acquired syphilis, occurring with alopecia and the eruption on the chest, or just after these symptoms. It is apt to have a stormy course. It may limit itself to one eye, but is more likely to affect both. There are no pathognomonic evidences that a given iritis is syphilitic. We judge as to this from the presence of other constitutional symptoms, or the existence of a constitutional history. A gummy tumor on the iris, might be said to be positive evidence of syphilis, were it not that eminent pathologists (Virchow) decide that such tissue growths also may

be non-specific. It is, however, entirely exceptional if the little grayish-yellow nodule on the iris, known as a gumma, is not specific in character.

Iritis may arise idiopathically in rheumatic or gouty subjects in whom there is no syphilitic taint. It may occur as a so-called metastatic condition in pneumonia, in gonorrhœa. This latter form deserves especial notice.

Local Symptoms.—(1) The rosy zone of fine conjunctival vessels radiating toward the cornea is one of the most marked symptoms of iritis. Besides there is always more or less general conjunctival injection, but the secretion is chiefly watery.

(2) The iris, which has a peculiar and beautiful brilliancy of its own in health, is of a dull turbid appearance, even in the early stages. In the more advanced, it is decidedly discolored and dirty in appearance. A light-colored iris assumes a greenish hue, and dark ones become brownish in color. This discoloration is partly due to hyperæmia and plastic effusion, and also to turbidity of the aqueous humor, caused by an admixture of lymph or pus.

(3) Sluggishness of movement and contraction of the pupil. The former is caused by the weight the muscles have to carry in moving the iris. The contraction may be caused by gluing of its edges to the anterior capsule of the lens. Such adhesions are called posterior synechiæ. This latter symptom, or condition rather, may not always be detected until atropia is used to dilate the pupil, when it is shown in the unequal contour of the pupil, which could not be detected until dilatation occurred.

When the whole circumference of the pupil is thus adherent, the condition is called exclusion of the pupil. Sometimes, more especially in advanced and neglected cases, the whole pupil may be blocked up with inflammatory material, and the condition is known as occlusion of the pupil.

(4) Yellowish nodules on the iris, known as gummy tumors and almost exclusively appearing in syphilis.

This is the picture of ordinary plastic iritis, but there is another form less dangerous, because synechiæ are less likely to occur. This is characterized by excessive lachrymation and serous instead of plastic exudation (rheumatic iritis). When there is a deposit of lymph particles on the posterior surface of

the cornea, the condition is sometimes called Descemetitis or aquo-capsulitis.

(5) *Pain.* The severity of the pain in iritis is variable. It may be violent to a degree; what is known as neuralgic, extending over the forehead, side of the head, cheek and nose. If the ciliary body becomes greatly involved, as it is apt to be, ciliary pain is a marked symptom and great tenderness in that region (irido-cyclitis).

(6) *Impairment of vision.* The vision is always impaired both for the near and far (see John Green's observations[1]). If the choroid be more than hyperæmic as it always is in a case of iritis, and true irido-choroiditis occur, the situation is much more serious than if the iris be alone or chiefly affected. The vitreous humor becomes cloudy from hyalitis, and there is great loss of vision which may never be restored. This condition of irido-choroiditis is not generally found in idiopathic cases, but rather in traumatic ones, and generally leads to complete loss of the eye. If the synechiæ are too firm to be broken up by the use of atropia, it is also a serious condition, but not so serious as irido-choroiditis. But these synechiæ are always a source of strain on the accommodation, and they may at any time, with very little provocation, set up a new attack of iritis, which may finally destroy the eye.

There is a form of iritis, constitutional in origin, peculiarly obstinate to treatment, which is usually supposed to be dependent upon a gouty or rheumatic diathesis. It is insidious in origin, not being attended by pain, and the vascular injection is moderate; but the ciliary body and choroid become soon involved, the iris bulges forward like a miniature cupola, the vitreous becomes hazy, and finally sight is very much impaired—sometimes lost. On the other hand, I have seen marked improvement in such cases under general hygiene.

Suppurative iritis is seldom idiopathic in origin, but is usually a result of injuries, operations upon the iris, extraction of the lens, the entrance of foreign bodies, accidental wounds. It is a form of disease that soon involves the vitreous and choroid and destroys the vision. It is generally believed to be of micro-

[1] Transactions American Ophthalmological Society, quoted in the chapter on Myopia.

bic origin, although mechanical and chemical influences, such as act after operations, certainly play a part in certain cases, and suppuration occurs in spite of the most thorough aseptic precautions. The suppurative form of iritis, is often unattended by pain, or, if it occur, it is not intense, such as that occurring in the course of syphilis, gout, or rheumatism, or of foreign bodies. In suppurative iritis, all the characteristic color of the iris is lost in a dirty yellow color, with swelling of the tissue. These finally subside and leave the iris a discolored membrane, with the pupil blocked, the eyeball soft from disintegration of the vitreous humor. Atrophy of the globe may finally result.

Prognosis.—The prognosis in iritis, it will be seen from the foregoing, depends first upon the extent of the inflammation. If the iris be alone or chiefly involved, the prognosis is good. The eye may be restored to its full functional power, and show no trace of the inflammation that has threatened its existence. Even small synechiæ may be left, and the eye during a long life not again be attacked. But if the synechiæ be extensive or complete, if the ciliary body and choroid be involved, the vitreous humor very hazy, choroidal staphyloma may occur in the ciliary region, the eye be painful and tender, finally cause sympathetic irritation, and be removed in order to save the fellow.

The nature of the inflammation also has much to do with the prognosis. The prognosis is better in a syphilitic iritis, which is promptly recognized, than in the insidious forms of rheumatic iritis, occurring in gouty subjects. The prognosis in suppurative iritis, whether from operations or metastatic, is a hopeless one. We are obliged to give up hope of saving the eye as soon as the fatal symptoms of purulent infiltration are seen.

Treatment.—Syphilitic iritis should be energetically, promptly, and thoroughly treated. If the syphilitic manifestations or symptoms are present, this is generally done, but the practitioner may attempt local treatment alone and fail until he begins to use the antidotes of syphilis, mercury, and iodide of potassium. If the pain and vascular injection be severe, local blood-letting should be practised by the natural or artificial leech. Atropia is the sheet-anchor in all kinds of iritis. Scopolamine is also very efficient. Their early use is most important, as has been already said. Rheumatic iritis should

also be treated by constitutional means. Salicylate of soda is one of the best drugs in the treatment, also iodide of potassium, while the patient should drink alkaline mineral water, such as natural and artificial Vichy, Saratoga Vichy, and the like. For those who can, a course at certain baths, St. Catharine's in Canada, the Hot Springs of Arkansas, and Aix la Chapelle in Germany, is also to be advised. In short, the most approved regimen for a rheumatic diathesis should be adopted. Opium will also be required in the early stages of severe cases. The patient should not be confined to his room in proper weather any longer than is actually necessary, especially if he is not very robust. Blue or smoked glasses, veils (for women), broad-brimmed hats, are to be used. Wind is a great foe to diseased eyes. In extreme cases, if one eye alone be affected, it may be bandaged while the patient is exercising out-of-doors. It need hardly be said, that it is necessary to keep the bowels free during the whole course of treatment. Warm baths and vapor baths (Turkish) are also necessary and valuable during the treatment. If the patient be an habitual user of tobacco by smoking, and craves it inordinately, he may be allowed to smoke moderately in a ventilated room alone, if his eyes be covered. Sitting in a room where others are smoking is in the highest degree dangerous. The diet should be nutritious and varied. Alcohol should not be allowed, except in very much run-down subjects, with asthenic forms of iritis, when whiskey in milk two to three times a day, will be found to be a valuable adjuvant in the cure of inflammations of the uveal tract.

Hot fomentations are very useful in the acute stages of the disease. Cocaine added to the atropia is also useful. Paracentesis of the cornea, is sometimes necessary, in order to secure full dilatation of the pupil by atropia.

Relapses of iritis, especially of the rheumatic form, are very common and very troublesome. They are often dependent upon synechiæ, which always render the eyes very sensitive to accommodative strain, and also upon constitutional conditions, that is to say, poverty or deterioration of the quality of the blood from syphilis or rheumatism. Each case of a relapse must be treated as an attack of the original disease, while the interim of freedom of the eye from inflammation, should be used in ap-

propriate constitutional and hygienic treatment to prevent the recurrence of the disease. This is not always possible. The prognosis should therefore be a guarded one in many instances, for, in spite of the most assiduous care, certain cases will finally end in a blocking of the pupil and consequently nearly complete loss of sight.

It is proper to say, that some practitioners of eminence advise the treatment of syphilitic iritis by local means alone, atropia instillations, hot fomentations, and so forth. I have been as yet unwilling to give this system a trial, believing as I do that mercury is an antidote to the poison of syphilis.

GONORRHŒAL IRITIS.—This occurs occasionally in the course of urethritis, especially of that which has associated with it inflammations of the joints. It is rather a rare disease. Locally it should be treated as the other forms.

TUMORS OF THE IRIS.

Cysts of the iris may occur as transparent vesicles on the surface of the iris, being attached by a broad base or by a small pedicle. The proper treatment is excision of the iris, to which the cyst is attached.

MALIGNANT TUMOR OF THE IRIS.—Sarcoma of the iris may occur in extremely rare cases. I saw one involving nearly the whole anterior surface of the iris, of a bright-red color, in a well-nourished woman of forty years of age. It began seven years before she came under my observation, at the ciliary margin of the iris. It was described as a bright-red spot as large as the head of a pin, which did not increase in size for five years, when it began to enlarge after what seems to have been an attack of iritis. Blood-vessels were distinctly to be traced in the growth, which nearly filled the anterior chamber. The cornea was healthy. The visual field was uninterrupted. The tumor grew while under my observation, but the patient declined an operation and disappeared from observation. A chromo-lithograph accompanies the report of the case.[1]

Enucleation of the eyeball is the proper treatment for all suspicious tumors of the iris that reach any considerable size. In very minute growths, we may be content with excising them, with the part of the iris involved.

[1] Transactions American Ophthalmological Society, 1869.

CHAPTER XVIII.

DISEASES AND INJURIES OF THE CILIARY REGION AND CHOROID.

Foreign Bodies in the Eye.—Their Removal Not Necessarily Insuring the Eye from Sympathetic Inflammation.—Sympathetic Irritation to be Distinguished from Sympathetic Inflammation.—Nature of the Latter.—Origin.—Metastatic Choroiditis.—Rupture of the Choroid.—Sarcoma.—Tuberculosis.—Panophthalmitis.—Irritation of the Choroid.—Hyperæmia.—Choroidal Hemorrhages.—Choroiditis.

FOREIGN BODIES IN THE EYE.—SYMPATHETIC IRRITATION AND INFLAMMATION.

In this chapter, I have grouped together the inflammation and injuries of the ciliary body and the choroid, together with the all-important subject of foreign bodies in the eye, because it is a natural clinical relation, just as, is found in practice. Wounds and injuries of the eyeball are serious and important according as they are in or near the ciliary body, and in proportion as they involve this part of the eye. Cyclitis has been discussed in treating of iritis in the preceding chapter. It is only necessary to say here that there may be ciliary injection and ciliary tenderness for some time, without any marked involvement of the iris. This is what is meant by cyclitis. Cyclitis is also associated with keratitis in many cases, and always with iritis. Cyclitis is scarcely an independent disease. In some cases a ciliary injection persists for a few days, without appearing to further involve the iris or choroid, of which the ciliary body is the connecting link.

Treatment.—Local depletion, hot fomentations, and atropia or scopolamine, together with the use of leeches and some form of opium, if the pain be severe, form an efficient system of treatment. Cyclitis which does not readily yield to this treatment soon involves the iris or choroid, or both, in true inflammation, as it probably did in hyperæmia, after the cyclitis has set in.

FOREIGN BODIES IN THE EYE.

A wound or a foreign body in the ciliary region is the most unfavorable injury, short of suppuration of the whole cornea, or detachment of the retina, with which an eye may be affected. A foreign body should be removed by forceps or other instrument, by a magnet, if of steel, in the most delicate manner, at as early a period as is possible; but the patient or his friends should be warned that the early removal, or the clean removal, by no means destroys the danger of a sympathetic irritation, which may arise at any period, from one week to fifty or more years after the injury. If the wound have greatly involved the cornea, if the iris be prolapsed, the lens and vitreous injured, and the vision, from hemorrhage, or cataract, or detachment of the retina, or from vitreous opacities, be reduced to perception of light—in fact, the eye for visual purposes is hopelessly lost, it is better to save the patient the tedious suffering of weeks of panophthalmitis, and induce him to have the eyeball enucleated at once. If, however, the wound be a cleanly cut one, or the foreign body has been removed, and especially if it be non-metallic, it is proper to endeavor to save the eye, always being on the lookout for sympathetic irritation of the fellow-eye. It is now generally believed that the chief source of inflammation in the eyeball is the septic character of the foreign body, and that the inflammation of the fellow-eye, when it occurs, is from the passage of microbes into the circulation from the septic organisms introduced into the injured eye by the foreign body, or the instrument inflicting the injury. Yet this general belief cannot be said as yet to be founded upon fixed facts. The first investigations which seemed to settle the microbic origin of sympathetic inflammation (Deutschmann) have not been confirmed by other observers. That there must be a mechanical cause, as well as in some instances chemical causes, the most superficial observation will show. The laceration and bruising of tissues, the chemical changes in the metallic substances, occurring after they have entered the eye, must of themselves excite inflammation.

The methods of removal of foreign bodies from the eye, depend naturally on their situation. If lying in the sclera, or

just beyond it, it is simply necessary in many cases to remove them with forceps, having, perhaps, enlarged the wound with knife or scissors. If lying in the vitreous or the retina, and they can be thus seen with the ophthalmoscope, they may be removed by an appropriate incision and the use of any convenient instrument—hook, spoon, or the like. In many other cases, provided the foreign body be a metallic one, a magnet may be

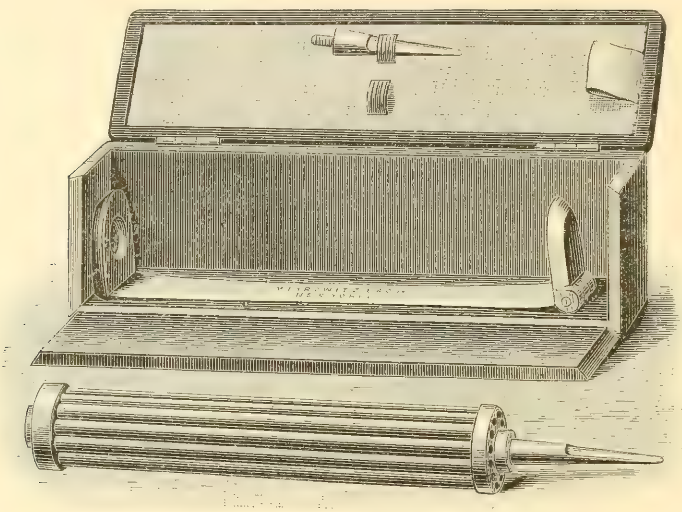

FIG. 145.—GRUENING'S MAGNET.

used. Among the most convenient of them is one invented by Gruening of New York, which has proved itself an efficient instrument.

The patient should be under ether when such an operation is undertaken, if, as is the case in rare instances, the body may be positively located in a certain part of the retina, so that the incision through which it is to be grasped may be made, while the observer is using the ophthalmoscopic mirror.

I have been surprised at the apparent exultation, with which cases of removal of foreign bodies from the interior of the eyeball have been reported, even when these foreign bodies are situated in a dangerous part of the eye. A graphic method of presenting to the student the possible consequences of an injury of the eyeball from a foreign body, is to consider the ciliary

region the danger line. The nearer foreign substances penetrate this line, the greater the danger of sympathetic irritation: for example, a foreign body in the cornea or in the lens has no especial danger, except as regards the integrity of the eye which is injured. Sympathetic irritation will not occur as the result of the injury; but if the foreign substance be in the iris, or behind, in the choroid, the danger is very considerable, while in the ciliary region itself it is of the most threatening kind. As I have before stated, the early and complete removal of a foreign body within this danger line, by no means removes the liability to sympathetic inflammation. Those who report successful operations for removals should remember that in only a few months, or possibly in years, the consequences of the wound, not necessarily of the foreign body, may be felt, and the removal of the eye be necessitated, for this wound shrinks and contracts, and with it brings the dangers that have been before alluded to.

An interesting suit for malpractice, in which I was once a witness, turned on this very question, whether the instantaneous removal of the foreign body, would have averted the sympathetic inflammation which occurred a long time after. The surgeon was unable, at his first examination, to find the missile which had entered the eye, and it was not removed until sympathetic irritation had set in. I was able to state my belief that, no matter when the foreign body had been removed, it being of itself of a septic character, and having produced a wound in the danger line of the eye, it would, in all probability, ultimately have been followed by the consequences that did follow. I am happy to say that the suit for malpractice was not sustained. It should also be stated that the search for the foreign body was made before the days of the magnet. It probably would have been discovered at an earlier period, had this instrument been invented.

SYMPATHETIC IRRITATION OF THE FELLOW-EYE.

This affection should be carefully distinguished from sympathetic *inflammation*. The symptoms of sympathetic irritation may arise in a few days after the injury of the eyeball, but they are much more likely to occur some weeks after the

injury. It is generally believed, that it is the contraction of a cicatrix, or a new inflammatory process about a foreign body which excites the sympathetic irritation. If we accept in full the microbic origin or septic origin of the disease, it is due solely to the transference of septic material from one eye to the other. In some cases, years may elapse before a true sympathetic irritation arises. There may also be cases when several attacks of sympathetic irritation occur during a course of years. In some cases, sympathetic irritation may never occur, and yet a foreign body be in the eye in the ciliary region itself (Roosa[1]), and cause only inflammation of the injured eye, but such cases as these are entirely exceptional. In the majority of cases, sympathetic irritation after a wound in the ciliary region or near it, occurs within a few months. One should always be on the lookout, as suggested by Wecker, for asthenopia in the fellow-eye, dependent upon an error of refraction, but simulating, in failure of accommodation, a sympathetic irritation. The symptoms of sympathetic irritation are:

1. Lachrymation.
2. Weakness of the accommodative power and diminution of the range of accommodation.
3. Hyperæmia of the conjunctiva.
4. Photophobia.
5. Tenderness of the eyeball, especially in the region of the insertion of the superior rectus muscle.
6. Painfulness and tenderness of the injured eye.

It is not necessary that all these symptoms should be present, in order to constitute sympathetic irritation, but failure of accommodation, photophobia, and tenderness of the injured eye are seldom wanting in any true case. None of these symptoms are evidences of true inflammation. There is no exudation, no sluggishness of the pupil, no discoloration of the iris. These later symptoms in the fellow-eye, indicate a much more serious condition, which no one should overlook.

Sympathetic inflammation of the eyeball, usually takes the form of irido-choroiditis. The first step in the disease is a cyclitis; this is generally followed by iritis, the iris becoming

[1] Boston Medical and Surgical Journal, March 30th, 1893.

changed in color, swelled, and not easily moved; then the choroid becomes involved. This is shown by the exquisite tenderness of the eyeball above the cornea and the turbid or hazy vitreous humor. There is a tendency toward rapid plastic effusion, which soon glues the tissues together and destroys their functions. The iris is attached to the lens and becomes atrophied and rotten. It may be drawn backward by adhesions, or bulged forward like a miniature dome, and obliterate the anterior chamber. There is also ciliary congestion, photophobia, lachrymation, with rapid loss of sight. Pain may be severe or dull, or scarcely present. Pain cannot be said to be a marked characteristic of sympathetic irido-choroiditis, but there is, as has been already said, exquisite tenderness of the ciliary region. The tension of the eyeball is increased at first, but it becomes lessened as the eye degenerates. The horror of this disease is, that it is scarcely ever restrained by treatment. Mercurial inunctions, pilocarpine injections, with iodide of potassium, and the local use of leeches and atropia, have been the means which have saved those eyes that have been saved in any degree, after sympathetic irido-choroiditis has set in. If the injured eye be ruined, it should be enucleated, but this will generally be of no avail when inflammation has followed irritation. If the injured eye has even useful vision, it should not be removed; for cases are on record where this eye has kept the patient from blindness, it having some sight, when the sympathetically affected one has been lost. But it is always better to remove a blind eye from which there is the slightest risk of sympathetic ophthalmia.

It is still a disputed question, as to how sympathetic inflammation arises, and what course it takes. Deutschmann published the results of many observations upon rabbits, which went to show that it originates in bacteria and travels by the sheath of the optic nerves. But his observations have not been confirmed, although several observers have followed up these investigations and made them anew. The weight of testimony is on the side of the origin of the disease being in the ciliary nerves, and that the process is either a reflex or metastatic one, from one set of ciliary nerves to the other. The evidence for this is found in the following clinical facts:

I. The disease arises almost always from injuries in the

ciliary body or region, or from injuries which extend to this part of the eye, or from injuries that cause stretching or distention of the ciliary region. As has already been shown, the ciliary region is the danger line, and injuries in other parts of the eye are more or less likely to produce sympathetic irritation, according as they are near this part. An injury through the cornea and the lens, which does not extend to the vitreous humor or choroid, seldom, if ever, produces sympathetic irritation.

II. The disease of the other eye, almost invariably appears as an irido-choroiditis. It is true that a few cases of sympathetic neuro-retinitis have been reported (Pooley), but these cases find few followers, and the usual type of sympathetic irritation is as I have indicated. From a careful consideration of these cases, it has always seemed to me that they may have had their origin in the ciliary region, but that the symptoms then were not marked, and that the neuro-retinitis in the marked cases that have been reported, was secondary to the initial disease.

The weight of evidence seems to turn toward a specific bacterial or septic influence at least, in causing sympathetic inflammation. This is indicated by the fact that certain aseptic substances, such as grains of powder, do not set up irido-choroiditis in the eye which they enter (Lawson). Sympathetic irido-choroiditis, when once set in, seldom leaves the eye, until sight has been abolished. Yet in a few instances a remnant remains. In others, the sight of the injured eye remains to some degree, while that of the sympathetically affected eye is totally destroyed. When an eye is attacked with sympathetic irritation, the eye causing it should be at once enucleated. Various substitutes, division of the optic and ciliary nerves, removal of the ciliary part of the eye, have been suggested, but they are not safe substitutes for enucleation of the eye causing the irritation. Well as it would be had we a substitute for enucleation, and true as it is, that not even danger of sympathetic inflammation disappears by the removal of the offending eye, it is the best thing to do. Doubtless eyes have been removed that might have been saved. Be this as it may, many have come to perfect blindness on account of a neglect or disobedience of this rule of early removal when sympathetic irritation has occurred. If we wait for sympathetic irido-choroiditis, it is then too late. Those who have seen this

catastrophe occur, find it a horrible one. If the injury of the eye be such as to have destroyed it, and if it be an injury in the danger line, the eyeball should be removed at once, especially if panophthalmitis be likely to occur. An early removal will save the patient much needless suffering. There has been thought to be considerable danger of meningitis, in the removal of eyeballs affected with panophthalmitis, but more exact observations of late (Noyes[1]) do not show this to be correct. It is probable that the danger is very slight. The stages of panophthalmitis are very slowly passed over. It is from a week to twelve, or even twenty, days, before the severe symptoms are over. Free incisions into the eyeball and connective tissue are of some service by lessening the tension. Hot fomentations will be required after the first few days of severe swelling. A poultice of flaxseed meal or similar substance may be applied for hours to lessen the agonizing pain by softening the tissues. Anodynes will also be required, while the patient's general health is carefully looked after. Finally, when the stump has shrivelled and become quiet, it may be removed for the sake of the appearance; but there is little danger of sympathetic ophthalmia from such an eyeball, unless the original injury was in the ciliary region. Yet it is to be remembered that any shrivelled eyeball may take on degenerative processes in the ciliary region, such as the formation of bony plates in the choroid, that may lead to sympathetic irritation. Usually, however, eyes that have suffered no wound do not produce sympathetic inflammation.

METASTATIC CHOROIDITIS.

Plastic and suppurative choroiditis, may arise in the course of various constitutional diseases, chief among which are pneumonia and cerebro-spinal meningitis, as well as in traumatic lesions communicating with the blood channels and producing septicæmia or pyæmia. The vitreous humor soon partakes of the inflammation, the retina becomes detached, and the whole eyeball disorganized. The process is not usually a very painful one, or, if it be, it is masked by the symptoms of the general disease. The prognosis is bad. *Treatment* can be only palliative. The mode of origin is through the blood-vessels.

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[1] Noyes: "Diseases of the Eye," p. 500.

TUMORS OF THE CHOROID.

Sarcoma is the most frequent form of choroidal tumor. Early enucleation is indicated, lest the growth extend outside of the eyeball. But cases occur where the sarcoma of the choroid is secondary to sarcoma of the breast or of other parts of the body.

Tuberculosis of the choroid may occur in acute tuberculosis.

COLOBOMA OF THE CHOROID.

This generally exists in connection with coloboma of the iris and the ciliary body. By the ophthalmocsope, it is seen as a white cleft in the fundus, with well-defined brownish edges, running from the ciliary region toward the optic disc.

Retinal vessels may be seen running across, or dipping into it.

SUPPURATIVE CHOROIDITIS OR PANOPHTHALMITIS.

Inflammation of all the tissues of the eye with suppuration in the choroid and vitreous, may be induced by injuries, and by operations. Having begun, it soon takes on a violent form.

Panophthalmitis is characterized by great swelling of the conjunctiva and connective tissue which produces exophthalmos, chemosis, haziness of the cornea, great tension of the whole orbit, and subjectively by horrible pain in the eyeball and surroundings, with increase of the general temperature of the body.

Such a condition of things when once established is hopeless as to any preservation of vision. If left to run its course, it ends in absolute blindness with atrophy of the globe. If the patient be seen early in the stages, the eyeball should be enucleated.

RUPTURE OF THE CHOROID.

Rupture of the choroid is a rare injury, occurring as a result usually of direct violence to the eyeball. The ophthalmoscopic picture is a better account of the injury than a detailed description. There may be one or more in the same eye. They are white, because the sclera shows through the rupture. They usually involve the retina, as shown by the disturbances and impair-

ment of vision. One such was lately seen in the practice of Dr. Frank N. Lewis and myself. The patient was a hackman who was hit upon the temple by an umbrella-handle, in the hands of an assailant.

IRRITATION OF THE CHOROID.

Under this term, Loring[1] describes a condition which he thought occurred in eyes suffering from overwork or exposure, and which comes under the term asthenopia not dependent upon errors of refraction or muscular weakness. I am inclined to believe that asthenopia may be so severe, as to cause choroidal irritation, and that the latter is not to be considered as an independent condition. At any rate, it is a diagnosis that should only be sparingly made and then by an expert in ophthalmoscopy. The principal, if not the only, ophthalmoscopic sign, according to Loring, is at the optic disc. There is a peculiar congestion of the surface of the optic papilla, in the region of the connective tissue surrounding the central vessels. "The connective-tissue ring," Loring continues, "is not obscured at the outer border of the nerve, as in retinal irritations, but it is more conspicuous." The choroid is not further implicated in what is thus called choroidal irritation.

HYPERÆMIA OF THE CHOROID.

Whatever may be thought of the ability to make the diagnosis of choroidal irritation, choroidal hyperæmia constantly occurs, and is readily recognized by any competent ophthalmoscopic observer. Then there is an actual overloading of the vessels of the stroma of the choroid. This is seen at the disc and in the connective-tissue ring, and although many observers deny that it can be detected in the choroidal vessels or in the tunic itself, Loring asserts that this has been done. The practised ophthalmoscopist finds it more and more difficult to make a mental standard, or paint a picture of congestion of the choroid. There are many variations in the fulness of choroidal and retinal vessels in perfect health of the eye. It is difficult to say when congestion or hyperæmia begins. The young observer

[1] "Text-Book of Ophthalmoscopy," Part II., page 250.

makes many diagnoses of choroidal congestion, which he qualifies in his examinations of mature years. With the subjective symptoms from overworked eyes, fresh in his mind from the history of the patient, it is easy to recognize what we naturally expect to find. But many of the symptoms that cause us to believe that we have hyperæmia of the choroid, are sometimes relieved by correction of errors of refraction. But it is wise to remember that overworked eyes require rest, as well as proper glasses, and that over-use may have caused choroidal irritation or hyperæmia.

Treatment.—The diagnosis of irritation of the choroid or hyperæmia independent of strain of the eyes from uncorrected errors of refraction, being made, rest becomes a highly important element in the treatment. The patient should be advised to stop all reading and writing; if weather permit, to seek diversion and employment in the open air. If photophobia be present, colored glasses may be advised, or other protection from glare; but in ordinary cases of mere hyperæmia of the choroid, this will not be necessary. A few days of rest with inquiry into the probable cause of the overloading of the choroidal vessels, and an attention to this, will probably soon bring the case to a successful end, unless there be constitutional conditions that preclude entire recovery.

CHOROIDAL HEMORRHAGES.

Hemorrhage into the choroid is not so often seen as in the retina. Loring[1] believes that there is something in the construction of the walls of the choroidal vessels, that does not allow of an escape of blood so easily as from the retina. The diagnosis of choroidal hemorrhage is made from the fact that the retinal vessels may be seen running over the spot where the blood is effused. Sometimes, the hemorrhages are in both the retinal and choroidal vessels. It is not easy to say whether a given hemorrhage is in the choroid or outer layers of the retina.

Treatment.—This is chiefly expectant. The blood may be absorbed, but the tissue is apt to be greatly damaged.

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[1] *Loc. cit.*

CHOROIDITIS.

This may be divided into two forms: serous and plastic. In serous inflammation of the choroid, there are generally opacities on the posterior surface of the cornea, and in the vitreous humor that prevent a full view or any good view of the choroid. When the media are clear enough to permit examination, we find marked changes in the fundus. There are spots of atrophy and exudation surrounded by pigment, or the tissue is thinned *washed-out tissue* (Loring[1]) with punctate appearances of pigment scattered about. These changes are chiefly seen at the anterior part of the eye. There is also a cloudiness of the back part of the vitreous, complete disorganization of the back part of the eye. Detachment of the vitreous and retina may occur.

Treatment.—If the general strength of the patient allow, this should be decidedly antiphlogistic; local blood-letting, inunctions of mercury, and hypodermic injections of pilocarpine are to be resorted to. If the case be not violent but insidious, and in persons somewhat reduced in general health, it is better to confine one's self to the internal administration of mercury bichloride, in smaller doses, long continued, and to colored glasses. The cause of the choroiditis, will naturally have much to do with the character of the treatment. If it be a traumatic one, general and local hygiene, until the disease run its course, will sometimes be the only treatment required; but even traumatic cases are often benefited by active internal treatment, especially by the use of hypodermic injections of the muriate of pilocarpine. This should be begun with a small dose, in an adult five minims of a two-per-cent solution. The dose should be increased until active sweating is produced after each application, and maintained at this from ten days to three weeks, according to the patient's improvement and strength, and so forth.

In the course of cerebro-spinal meningitis, severe inflammations of the choroid and retina may occur. They may be suppurative in character, and lead to the detachment of the choroid and retina. Fortunately, they often attack but one eye. But in a given contingent of cases, a certain proportion of

[1] "Text-Book of Ophthalmoscopy," Part II., p. 252.

eyes are affected. The eyelids may present the appearance as seen in purulent ophthalmia. There is also conjunctivitis and photophobia, and there may be inflammation of the cornea. In an epidemic occurring in the vicinity of Heidelberg, from four to five per cent of the sick were affected with an intra-ocular disease, described by Knapp. Of eighteen cases seen by him, blindness resulted in every case but one. Knapp regards the disease as a plastic choroiditis, with consecutive detachment of the retina. Other observers confirm these observations. Some consider it to be a purulent inflammation of the iris, ciliary body, and choroid. It is very important that the eye should be examined with the ophthalmoscope in the very beginning of any ocular symptoms, if only for the prognosis.

Dr. Randolph[1] reports thirty-five cases of meningitis in which the eyes were examined. The predominant trouble in the cases observed by him, was congestion of the retinal veins and optic disc. In two cases the eyes were normal, in one there was hemorrhagic retinitis, with thrombosis of the central vein. Randolph thinks that every extensive epidemic is apt to be associated with a special type of eye affection. It certainly is remarkable that four observers preceding him, of whom Knapp was one, most often observed suppurative inflammation of the uveal tract, and make no particular mention of any other diseases of the eye. Four other observers, of whom Niemeyer and Ziemssen were two, met with a keratitis, while in the cases observed by Dr. Randolph, tortuosity and distention of the retinal veins, and more or less congestion of the optic disc, were the marked symptoms. Of Dr. Randolph's thirty-six cases, not counting those which had double vision, only three complained that they could not see distinctly.

Prognosis.—The prognosis is scarcely ever entirely favorable for complete recovery, that is, with full integrity of the eye, in plastic choroiditis. The ravages of the disease, even when a fair degree of vision remains, are seen in the ophthalmoscopic picture of atrophy, displaced pigment, and so forth (see colored plate No. VI.).

[1] Bulletin of the Johns Hopkins Hospital, 1893.

CHAPTER XIX.

DISEASES OF THE RETINA.

Hyperæmia of the Retina.—Hyperæsthesia.—Anæsthesia.—Retinitis.—Albuminuric Retinitis.—Suppuration of the Retina.—Retinitis Pigmentosa.—Detachment of the Retina.—Epilepsy of the Retina.—Glioma.—Retinitis Hæmorrhagica.—Injuries of the Retina, Concussion, Cysts, Dazzling.

Retinitis, or inflammation of the retina, exists in various forms and as a consequence of various diseases. It may occur independently, that is, quite apart from other inflammations of the eye, but it is more frequently associated with diseases of the optic nerve, the choroid, or the meninges of the brain. It arises in the course of Bright's disease, diabetes, leukæmia, syphilis, and other constitutional diseases.

HYPERÆMIA OF THE RETINA.

It can scarcely be denied from subjective symptoms, and from analogy with the affections of other parts of the body, that there may be a hyperæmia of the retina, but this is difficult of positive diagnosis with the ophthalmoscope, and is to be inferred rather than demonstrated. It may be caused by certain drugs, prolonged exposure to a glare of light, by fine work on near objects, especially if there be an uncorrected refractive anomaly, usually hyperopic or mixed astigmatism. The whole fundus oculi looks too red, in hyperæmia of the retina. The arteries may be enlarged, and the smaller branches more numerous. To estimate the latter, it is well to adopt Jaeger's plan of counting the vessels, and comparing the number with those of a normal eye. The veins usually pulsate. The eye itself is irritable and easily fatigued, and dreads even ordinary daylight. The optic papilla gives a general appearance of being flushed.

Treatment.—The indications are to search out the cause and remove this, if possible; when, with rest and shading of the eyes

with colored glasses, and so forth, the eye may soon recover. Passive venous congestion of the retina, may occur from any obstruction to the outflow of venous blood. The veins then are large, tortuous, dark, and pulsating.

HYPERÆSTHESIA OF THE RETINA.

There are cases in which the retina is over-sensitive to light, phosphenes are seen, the retinal image remains unduly long, spasm of the orbicularis muscle occurs, neuralgia is complained of, and yet no lesion of the retina, nor of the other parts of the eye is discovered. Exact examination generally shows, that the greater number of these cases have a lesion that may be found, yet there are probably some in which our present means of examination, or the present state of our knowledge, fails to detect anything, and yet when the refractive errors are corrected, these symptoms remain. They may, with reserve, be put down in the class of retinal irritations and hyperæsthesia.

Treatment.—Such cases should be treated by rest of the eyes, with pleasant mental occupation, the use of tonics, especially strychnine and iron, change of air, and so forth.

ANÆSTHESIA OF THE RETINA.

Blunting of the perceptive power of the retina, may occur as a result of injuries, such as concussions, blows, lightning stroke, disease of the eye (*amblyopia ex anopsia*), as in squint, neuralgia of the fifth nerve, and in old age. Like hyperæsthesia of the retina, the frequency of this disease is exaggerated. It is a very rare affection, except possibly in strabismus, when its existence is still an unsettled question. Malingerers come into consideration in this connection, as well as in diseases of the optic nerve, for they are apt to claim insensibility to light and impressions on the retina, when no lesion is found, and yet it is impossible on account of the occasional occurrence of amblyopia without lesion, to say in all cases, whether or not those who claim to be blind are actually malingerers. Some of these cases clear up by complete recovery. In others, lesions are slowly developed, which show that a morbid process is making its way into the tissues of the retina. The distinctness of vision, is sometimes very much im-

paired in these cases; with poor light they see much worse proportionately (hemeralopia) (ἡμέρα, day; ὄψις, vision). In cases of anæsthesia from squint, systematic exercise of the eye is to be advised (Javal). This subject will be more fully treated of under the head of Strabismus.

RETINITIS.

This disease is characterized by the following ophthalmoscopic appearances:

1. An opacity of the retina. This varies in intensity from the appearaance of a very delicate mist or film (veiled appearance) to that of a dense white patch of exudation.

2. The edges, particularly of the optic papilla, are blurred.

3. No marked change is seen in the early stages in the calibre of the arteries, but the veins are distended and tortuous.

4. Exudations are seen along the course of the vessels and sometimes over them.

5. There may be blood extravasations, irregular in shape, and of a bright red color. If they are situated in the inner layers, among the nerve-fibres, they are striated and have feathery edges. If they are in the outer layers, they are more smooth and uniform.

Besides these symptoms, in specific forms of inflammation or degeneration of tissue, such as occur in Bright's disease, there are peculiar changes, pathognomonic of constitutional affections, which will be described in speaking of diabetic and albuminuric retinitis.

The vision in retinitis is variously impaired. It is not always possible from a given ophthalmoscopic examination, to say how much we shall find the vision impaired. With an apparently slight lesion, we may find the vision much reduced; on the other hand, with very marked and extensive changes remote from the macula, or even near it, the vision may be $\frac{20}{20}$. Subjectively, the patients complain of dull heavy pains, and a vision as if objects were seen through a veil, mist, or haze. The disease may run an acute course, and may end in nearly perfect resolution, or in atrophy and blindness.

Causes.—Retinitis may depend upon exposure to a glare of

light, in tropical countries especially, or to the snow, or moon. Sailors are particularly liable to this latter form. Syphilis very often produces neuro-retinitis or pan-retinitis. But there are no positive ophthalmoscopic appearances, by which we may distinguish syphilitic retinitis, from certain forms where syphilis has never existed. It occurs exclusively in acquired syphilis. Retinitis may occur and frequently does from extension of the disease from the optic nerve and from the choroid. Fortunately, retinitis usually attacks the connective tissue primarily, the nerve tissue last. The inflammatory material filters into the tissue, and then appears as an exudation, looking as has been already described.

The tissue of the retina after having been swelled and œdematous may undergo sclerosis, fatty degeneration, and atrophy. The extravasations of blood may be absorbed, or they may be changed into an opaque degenerated mass.

RETINITIS ALBUMINURICA OR NEPHRITIC RETINITIS.

This is a form of retinitis of such importance as to demand a separate notice.

The characteristic ophthalmoscopic appearances are:

1. Considerable exudation which soon undergoes fatty degeneration, especially in the region of the papilla.

2. A number of white or fawn-colored, glistening, stelliform spots are seen.

3. Numerous hemorrhages, generally irregular in shape. The peculiar appearances in Bright's disease, are late in the general degeneration of the tissues, which characterizes what it known under that head. Yet the ophthalmoscope may give the first positive evidence of the presence of this grave constitutional disorder. In several instances, I have diagnosticated for competent general practitioners the existence of Bright's disease, of which they were not as yet aware, when hemorrhages into the retina and the fawn-colored spots have occurred. The prognosis is usually bad. Indeed, these retinal spots generally indicate a speedy fatal result from the constitutional disease. Usually a very few months or even weeks supervene before the patient succumbs.

THE EYE IN ACUTE BRIGHT'S DISEASE.—URÆMIC AMAUROSIS.

Although it is well known that there is sometimes total loss of sight in the course of acute Bright's disease, the pathological conditions causing this are not known. It is described as uræmic blindness, but occurs, fortunately, infrequently. After some specific inquiries in the large hospitals of New York —Bellevue, Mt. Sinai, and St. Luke's, where the house physicians have shown me their statistics, and allowed me, at the instance of the attending physicians, Drs. Loomis and Beverley Robinson, to examine the cases in their wards—I found this to be the case.

Very little has been added to our knowledge of uræmic amaurosis since Graefe wrote[1] more than twenty-five years ago. In the amaurosis of acute Bright's disease, there is absolutely no change to be seen with the ophthalmoscope. Œdema of the retina, is certainly not to be considered. The merest tyro in ophthalmoscopy would detect this condition, did it exist. The two conditions, uræmic amaurosis and inflammation of the retina, with hemorrhages, may occur together, as I myself had occasion to observe in the case of a pregnant female, who became blind from uræmic amaurosis, but recovered so as to be able to read and sew for the five or six years after, during which she lived. She had retinitis albuminurica upon which uræmic amaurosis had supervened. As Foerster says, there is no difficulty in differential diagnosis. In retinitis albuminurica, the patients are going about and come themselves to the physician, but in uræmic amaurosis the physician goes to the patient. The general condition is so feeble that the patient is in bed. There is stupor, pain in the head, vomiting and general weakness, and *absolute blindness*. The pupil may or may not react well to light. When the pupil does react Foerster says that the optic nerve must be capable of conducting an impression, at least, up to the corpora quadrigemina. Graefe attempted to form a prognosis from the reaction of the pupil. It was thought to be better when the pupil moves on exposure to light. When the patient recovers from the general symptoms, the amaurosis is also usually completely recovered from. Those in which

[1] Archiv für Ophthalmologie, Abtheilung ii., p. 283.

complete recovery does not occur are probably mixed cases of retinitis albuminurica and uræmic amaurosis. This recovery separates these cases very distinctly from those of quinine amaurosis. Foerster thinks that uræmic amaurosis occurs most frequently in scarlet fever, and, next to this, in contracted kidney. It is not uncommon in pregnant women, having albumin in their urine. The uræmic amaurosis may be caused, as supposed by Frerichs and Traube, by blood-poisoning. Traube says there is increased arterial tension; that in consequence of the watery excess in the blood, there is great transudation into the cranial cavity, which leads to anæmia of the brain. The theory of Traube, seems a more probable one than that of blood-poisoning, which, judging from lead and quinine amaurosis, is more apt to harm the retina, than would a very temporary overfilling of the contents of the cranium. From our present knowledge, we may conclude that the blindness in uræmic amaurosis is absolutely without ophthalmoscopic appearances, and that if the affection be not complicated by the neuro-retinitis occurring in chronic Bright's disease, the sight will be fully restored after the patient recovers from the general symptoms. The exact nature of the morbid process producing uræmic amaurosis is, as yet, unknown.

RETINITIS LEUKÆMICA.

Ophthalmoscopic Appearances.—Round yellowish-white patches, sometimes with red borders, strewn about the periphery of the retina and near the macula. These are formed of masses of exuded white and yellow blood-corpuscles. The fundus is pale, and the arteries are also pale.

Suppuration of the retina may occur, but it is only interesting from a pathological point of view. It may be seen in examination of eyes that have had panophthalmitis.

RETINITIS PIGMENTOSA.

Pigmentary degeneration of the retina. This interesting condition, before the invention of the ophthalmoscope, was known as night blindness. Night blindness is a symptom occurring simply because the greatly impaired perceptive power

of the retina, demands an excellent illumination. This is necessary for vision of enfeebled retinal fibres. Retinitis pigmentosa is seen as an hereditary ailment. Numbers of cases occur in the same family or its branches. It is congenital, or begins in early childhood and runs a very slow course. For years, it may not advance at all, and the patient may live out his life with a reasonable amount of telescopic vision. If it be a severe case and combined with opacity of the posterior pole of the lens, the patient may be nearly blind and thus be prevented from occupations involving any vision of fine objects.

FIG. 146.—RETINITIS PIGMENTOSA. (SCHMIDT-RIMPLER.)

On the other hand, the patient may see well enough to get through with important affairs and pursuits. All this depends upon the extent of the lesions which constitute the disease.

Ophthalmoscopic Appearances.—The disease is characterized by paleness of the optic papilla, attenuated blood-vessels, and the scattering of pigment about the fundus, chiefly toward the periphery. The pigment assumes peculiar shapes, resembling sometimes the wing of a bat, or bone corpuscles. The stroma of the choroid appears very plainly, then also narrow black lines following the course of the vessel.

Treatment.—For advancing retinitis pigmentosa, there is probably no remedy. Fortunately, in many cases, the disease does not progress, or does so at a snail's pace, so that its subjects may live out their days with a modicum of vision, never becoming blind. Strychnia has some reputation in progressive cases, but I have been unable to verify its value.

The slow progress of retinitis pigmentosa, in well-nourished persons, is sometimes very noticeable. I have for the last fifteen years observed a prosperous gentleman having marked manifestations of this disease, with good central vision with correcting glasses, who during that time has never got any worse. It is

also remarkable that their visual fields can be reduced to such a telescopic point, and yet vision remain. The visual field of a lady seen first in 1886, who was then twenty-seven years of age, is shown below. Although she has such small fields—a little larger than is shown on the chart, when the finger is used in-

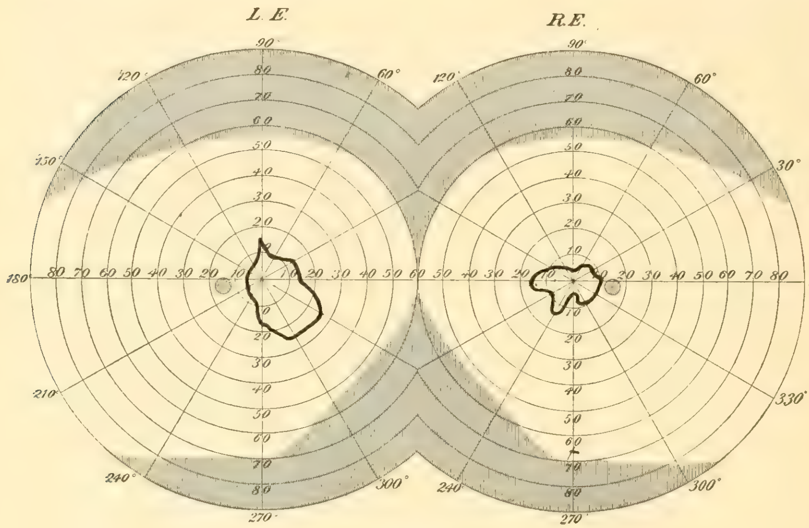

FIG. 147.—VISUAL FIELD IN A CASE OF RETINITIS PIGMENTOSA.

stead of the pointer, her astigmatism being corrected, vision is $\frac{20}{30}$ on one side, and $\frac{20}{40}+$ on the other. She is a lady in the higher walks of life, able to regulate her living in the best manner, and while she suffers considerable inconvenience, and is always anxious, she is not known, except among her most intimate friends, to have any impairment of sight. She has an elder brother in the same condition. She remembers to have been troubled to see at night since she was nineteen years of age, but she does not remember any difficulty in playing "hide and seek," "blind man's buff," and such games when she was a young girl. It seems, therefore, that the difficulty must have advanced as she grew older. This lady is exceedingly well nourished, and bears every evidence of health. The brother, a gentleman of fifty years of age, has much less vision, $\frac{21}{100}$ on one side and $\frac{22}{100}$ on the other, although he can read No. 1 Jaeger. He seems to have more trouble in every respect than his

sister, although, objectively, it cannot be seen that he is much worse. Of late, however, lenticular opacities have appeared.

DETACHMENT OF THE RETINA.

The retina may become detached from the vitreous in part or in totality. This is caused by traumatism or spontaneously. When idiopathic, it occurs as a result of long-standing inflammations of the choroid which have involved the vitreous humor and lessened its volume, so that the retina has lost its normal support. Effusion of inflammatory material, blood, and so forth, may also be an exciting cause. Tumors beneath it also detach it. Elongation of the eyeball, myopia, is a fruitful source of detachment of the retina. The stretching of the globe is perhaps not so much the cause as the chronic choroidal disease, that so often exists in conjunction with myopia.

Ophthalmoscopic Appearances.—In partial detachments, a greenish or bluish wave is seen in some part of the fundus, floating more or less forward. With the ophthalmoscope direct examination this will be found by measurement to project forward from the other parts of the fundus from one to more diopters. The retinal vessels bend over this and the red choroidal reflex surrounds it. In small detachments more lines of undulations are seen. In total detachment, the whole retina being thrown forward in funnel shape, a greenish-brown mass is seen, perhaps mingled here and there with glistening patches of cholesterin. This, usually, is a final result, and not a primary one.

Prognosis.—In traumatic detachments occurring in eyes heretofore healthy, reattachment may occur, with a diminution of the field of vision. Complete restoration of the fields even in these cases is very rare. The prognosis in idiopathic cases depends entirely upon the extent of the choroidal and vitreous disease. If this be slight, and the detachment has been induced by a traumatism, it is possible to secure union, which is more or less permanent, but on the whole, in idiopathic detachment, the prognosis is unfavorable. The detachment may increase until it is total; the eye may become painful and tense, and in rare cases it must be removed, either on account of unbearable pain, or lest it excite sympathetic inflammation of the fellow-eye.

Treatment.—In traumatic cases, the patient should be put on his back as soon as possible, and a protection bandage be applied. In ten to twelve days, we may expect reattachment; sometimes this is permanent.

In idiopathic cases, the recumbent position with hypodermic injections of pilocarpine may be tried. Puncture of the retina with a needle, at the point of greatest detachment, is also performed, with only moderate success.

EMBOLISM OF THE ARTERIA CENTRALIS RETINÆ.

Ophthalmoscopic Appearances.—The optic papilla is white, the blood-vessels small; the retina is opaque, except at the macula, where there is a bright red spot. Subsequently, the tissues atrophy and various changes are seen in the choroid and retina, cholesterin formations, and so forth. The subjects of embolism of the central artery find themselves suddenly blind, without apparent cause.

They are usually rheumatic subjects, and often have lesions of the heart. A few cases are said to recover. I have never seen a case of recovery in embolism of the central artery. Atrophy of the nerve and retina usually results.

Other ophthalmoscopic appearances may simulate embolism; for example, they may be caused by retro-bulbar neuritis optica and retro-bulbar hemorrhage. The first anatomical demonstration of embolism of the retinal artery was made by Schweigger[1] in one of Graefe's cases. Schweigger's observation was confirmed by Sichel, Nettleship, Priestley Smith, and Schmidt-Rimpler, in other cases. Iridectomy, paracentesis, and early massage of the eye (Mauthner) are recommended. Schmidt-Rimpler treated one case successfully, by first making a passage to the first nerve as in optico-ciliary neurotomy, and then making slight pressure upon the nerve with the strabismus hook.

EPILEPSY OF THE RETINA.

This name is given to a very rare condition, only known from subjective symptoms, because ophthalmoscopic examinations, which in the nature of things have been very seldom successful,

[1] Schmidt-Rimpler: "Ophthalmoscopy," page 251, American edition.

reveal nothing. The patient tells of a sudden dimness of vision advancing from the periphery of the field toward the centre, until total blindness results, which generally lasts but a few minutes and then completely disappears. The attacks occur at variable intervals and may affect one or both eyes. The condition is supposed to be due to spasm of the retinal vessels. It occurs in migraine.

GLIOMA OF THE RETINA.

(γλία, *glue*.)

This is a tumor of the retina which occurs almost exclusively in young children. It is often, on account of the youth of the subjects, unnoticed until far advanced. It appears as a bright grayish tumor projecting into the vitreous. It may be mistaken for detachment of the retina. The eye may have a normal appearance. As the tumor grows it breaks through the globe, as a fungous growth, and occasions great pain and suffering, until the patient succumbs.

Treatment.—Early enucleation is the only remedy, but this avails only to delay the disease, which extends to other parts of the body and becomes fatal, although in some instances many years have elapsed without a reappearance of the disease. It is possible, therefore, that a cure was effected in these cases.

INJURIES OF THE RETINA.

Retinitis Hemorrhagica.—It is perhaps more correct to speak of retinal hemorrhage than of retinitis hemorrhagica. Yet there are cases of hemorrhage from the retinal vessels, which produce or end in glaucoma. These occur chiefly in old people, and are to be regarded as a sign of general arterial degeneration. That hemorrhages occur in the retinal vessels in the course of Bright's disease has already been sufficiently spoken of. Indeed any form of retinitis may be associated with bleeding from the small vessels of the retina. Spontaneous hemorrhages unassociated with any known cause in the general or local (ocular) condition of the patient sometimes occur, and if not in the region of the macula may clear up, and leave the vision unimpaired.

Traumatism is a fruitful source of retinal hemorrhages,

which, if extensive, separate the retina from the choroid and ruin the eye, but injuries to the retina are much more apt to produce an injury ending in vasculitis or œdema than hemorrhage. Double-sided retinitis, resembling that from Bright's disease, was reported by McHardy, and quoted by Loring.[1] Acute œdema presents the ophthalmoscopic appearance of grayish or white patches which may quickly disappear. Certain injuries to the retina, although they may not at once produce impairment of the vision, afterward end in atrophy of the optic nerve. Loring[2] thinks that such injuries affect the optic nerve or even the orbit by *contre-coup*, and cause molecular changes in the nerve or even in the brain.

Rupture of the retina, without that of the choroid, has been known to occur. Loring saw one such case, when a gentleman was thrown from his horse, striking on his head. A large rent occurred in the retina passing through the macula, revealing the stroma of the choroid without rupturing the latter.

Cysts of the retina have been observed. They are easily mistaken for detachment. In one such case, that of the late D. F. Cocks, a large cyst completely disappeared, and eighteen months after had not reappeared.[3]

Dazzling of the Retina.—This occurs from prolonged exposure to the bright light of the moon on the deck of a ship, among sailors in the tropics, or from watching an eclipse without proper protection of the eyes. A single intense flash of light may cause retinitis. Certain unsteady electric lights are dangerous to the eyes on this account.

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[1] "Text-Book of Ophthalmoscopy," vol. i., p. 77.

[2] *Loc. cit.*

[3] *Loc. cit.*

CHAPTER XX.

DISEASES OF THE VITREOUS HUMOR.

Hyalitis.—Opacities of the Vitreous.—Muscæ Volitantes or Floating Bodies.—Mouches Volantes.—Myodesopsia.—Synchysis Scintillans.—Foreign Bodies.—Cysticercus.—Filaria.—Vessels of New Formation of the Vitreous.

WHILE hyalitis or inflammation of the vitreous humor, is seldom an independent disease, it presents phenomena of sufficient interest for a separate study, provided always that it is properly considered as an affection dependent in a large majority of cases upon irido-choroiditis, choroiditis, or cataract. Hyalitis is seen as a turbidity of the vitreous humor in various inflammations of the eye. The products of these inflammations, pigment, blood, may often be seen in the vitreous body. The ophthalmoscopic picture is a varied one. Sometimes the whole vitreous is so turbid that no reflex is seen. Again, the disc of the optic nerve and retina, are seen as though a cloud or veil or small particles pass up and down over the field. Again, the vitreous is filled with brilliant, glistening golden bodies which illuminate the whole field (synchysis scintillans) Membranes also sometimes form in the vitreous after extraction of the lens. It is rare to find a vitreous humor entirely free from disease; that is to say, entirely clear after extraction of cataract. The vitreous is rarely perfectly free from turbidity in advanced age.

PERSISTENT HYALOID ARTERY.—In rare cases, this vessel remains through life instead of disappearing before birth. It is seen as a brownish string, reaching from the parietal capsule to the optic papilla. The subject of foreign bodies in the vitreous, has already been quite fully discussed in the chapter on Injuries of the Choroid, and need not be further illustrated at this point.

Hemorrhages into the vitreous, occur among young men and young women, at the age of puberty, and in women at the climacteric, and from traumatism. The idiopathic cases very often end in full absorption of the blood, and in restoration of the

vision. The hemorrhage in idiopathic cases, is not usually so extensive, as to bring the vision down to a point where the patient cannot read coarse type, and go about readily without assistance. The treatment in these hemorrhages should be by rest of the eyes from any trying occupations; blue or smoked glasses should be worn; and general hygiene observed. As a drug, the corrosive chloride of mercury in small doses seems to have some efficiency in promoting absorption. If not, it is at least with a bitter tincture, such as the tincture of gentian, a valuable tonic.

Traumatic hemorrhages, unless very large, are usually absorbed. The prognosis as to sight in these cases, depends not so much on the vitreous, as on the damage that may have been done to the surrounding tissues.

A fluid vitreous is often found in senile cataract as a result of long-standing chronic inflammation. This is discussed under the head of Cataract. The fluidity of the vitreous greatly decreases the tension of an eye. It often exists to such a degree as to render the iris tremulous, an appearance which should be carefully looked for in making a diagnosis.

MUSCÆ VOLITANTES.—Objective opacities of the vitreous, that is, those that can be detected with the ophthalmoscope, constitute one variety of *muscæ volitantes*, but not the only form. Before the invention of the ophthalmoscope, it was of course impossible to differentiate the objective from the subjective *muscæ;* that there are subjective muscæ is without doubt. But it is probable that a more thorough examination than is sometimes made, would diminish the number of the latter. Yet in asthenopia, muscæ are seen in the air, on looking at the sky, on white paper, and in persons without asthenopia, for years, with no lesion to be discovered. These appear as beads, strings, and crescents. They are the constituents of the vitreous casting a shadow upon the retina and then projected. Muscæ are also seen in opacities of the lens. Certain muscæ in the anterior part of the vitreous humor, result from opacities of the capsule which have become loosened.

The entoptic investigations as to the form and situation of floating bodies in the vitreous, lost much of their importance after the invention of the ophthalmoscope. Being able now to detect

the slightest turbidity of the vitreous humor, and the smallest opacities of the lens and vitreous, we are able to give more decided opinion as to the nature and significance of muscæ. If they cannot be seen by the ophthalmoscope, no matter how graphically they may be described by the patient, we can believe them to be the constituent cells of the vitreous casting their shadows upon the retina. Although sometimes very disturbing to the patient, the surgeon may generally make them less so, by quieting his fears as to their significance. For, even if real bodies, they often disappear in time, and the less important ones do not always increase. Donders thinks that the want of acuity of vision of advanced age, is due in large measure to changes in the cells of the vitreous. In the lens, senile changes may impair distant vision without ever coming to the dignity of cataract.

Young subjects who are much troubled with muscæ volitantes or mouches volantes, as the French say, are usually below the normal in general strength or tone. In young men, and more rarely in young women, onanism, self-abuse, may contribute to this general condition. Yet it is to be remembered that the experts of our day, do not lay quite so much stress upon the very common masturbation among young boys, as was formerly done. Not so much evil is ascribed to these vicious and demoralizing habits, as was formerly the case among medical writers. Yet in this very matter of muscæ volitantes, the subject of sexual excess in adults, and masturbation in young subjects, should be considered and inquired into under proper circumstances. But in young girls especially, it is wrong to put lascivious ideas into their minds, by prurient inquiries unless under entirely exceptional conditions, and then they should be examined through one of their own sex.

CYSTICERCI.

In this country and Great Britain, the presence of cysticerci in the vitreous, or indeed in any part of the eye, is an extremely rare occurrence. I have never seen such a case. In North Germany, the disease occurs occasionally. According to Berry,[1] some statistics place the frequency as one in five hundred cases of diseases of the eye.

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[1] Treatise on the Eye, p. 322.

In the cases grouped together in this volume, obtained from the reports of American ophthalmic hospitals, very few have been observed. A cysticercus when in the vitreous, is said to develop between the retina and the choroid, when it causes detachment of the retina. It is only when perforation of the retina takes place, and the parasite escapes into the vitreous, that the diagnosis can be made. When the vitreous remains transparent, the vesicle can be distinctly seen, and its nature diagnosticated by the movements of the neck of the parasite, which is at times pushed out and drawn in. Irido-cyclitis is set up by the cysticercus and turbidity of the vitreous occurs. This of course renders a positive diagnosis impossible. The treatment consists in the removal of the parasite. If this be accomplished, the eyeball may be saved, without atrophy. If the exact situation of the cysticercus can be made out, the removal is much favored. Of forty-five cases operated upon by Alfred Graefe, of Halle, twenty were entirely successful. Hansen-Grut, of Copenhagen, records one case where the parasite was successfully removed and normal visual power was secured. According to Berry [1] two cysticerci have been found in one eye; but there is no record of both eyes having been affected with this disease.

Schmidt-Rimpler [1] traces the cysticercus to the *tœnia solium*. The links of the tape-worm are exfoliated, he says, and pass out with the fæces. The embryo, situated in the genitalia of the links, is found in the dung-heaps of meadows and fields, and from thence enters the stomach of man, or dog, or pig, in the food or water. Then it loses its covering through the action of the gastric juice, bores into the blood-vessels and wanders about the body; when it is fixed, it begins its second stage of development, when it becomes known as cysticercus. The cysticercus is a vesicle with fluid contents.

The cysticercus may become encapsulated in the muscular tissue of the hog; and if it enter uncooked the stomach or intestines of the human being, becomes a tape-worm. Schmidt-Rimpler thinks it improbable that the cysticercus develops from the embryo of the tape-worm, from the individual who carries

[1] *Loc. cit.*

[2] "Diseases of the Eye," English translation, p. 276 *et seq.*

the tape-worm. The embryos that reach the eye do so through the blood-vessels. This has been actually observed. Schmidt-Rimpler has had a case under observation for years in which the vitreous has remained normal, except a small scotoma. Cysticerci do not cause sympathetic irido-choroiditis, although slight sympathetic *irritation* has been observed. It is possible that cysticerci occur more frequently in this country, than has yet been observed. Dr. Cheatham, of Louisville, has lately reported a case, "the second reported in our country."[1] Certainly tape-worm is sufficiently common here, to lead us to be on the lookout for suspicious scotomata. The *filaria oculi* has occasionally been observed in the vitreous humor, as a thread-like structure. It is more common in Africa, from whence I have a fine specimen removed from the anterior chamber by a missionary physician.

VESSELS OF NEW FORMATION IN THE VITREOUS.—Loring[2] describes these as comparatively rare, but not so rare as writers have generally supposed. According to him, these are sometimes seen with a clear vitreous and give the idea of primary and independent affections. They reach far into the vitreous and scarcely have any visible attachments. Sometimes they are supported by a delicate web of connective tissue, which is so thin as to escape any but the most expert and close observation.

These vascular new formations are clearly the result of inflammation. Loring believes that they owe their origin to some kind of retinitis, in which the adventitia of the parent vessel undergoes a hyperplasia and then becomes vascularized. If the inflammation be severe, the vitreous is at first turbid, but it finally clears up. The ophthalmoscopic picture is then a beautiful one. Cases were seen by Loring in which the vessels seemed to "extend forward toward the observer like branches of coral, in a perfectly transparent fluid, with here and there a feathery membrane connecting different branches." Sometimes they appeared as "a short, thick red fringe" moving to and fro with the varying movements of the eye. The vessels were venous in character.

[1] Annals of Ophthalmology and Otology, vol. iii., No. 2.
[2] Loring, "Text-Book of Ophthalmoscopy," vol. ii., p. 40.

CHAPTER XXI.

DISEASES OF THE OPTIC NERVE.

Neuritis Optica.—Atrophy.—Amblyopia from Alcohol and Tobacco.—Colloid Degeneration.—Opaque Nerve Fibres.

INFLAMMATION of the optic nerve, optic neuritis, is rarely, perhaps never, an independent affection. It arises by extension from the meninges of the brain or from the retina and choroid. It also occurs as a result of the action of certain poisons upon the structure of the nerve. Pressure upon the nerve and obstruction to its vascular circulation from tumors of the orbit, foreign bodies, abscesses, periostitis of the orbit, are among the causes of optic neuritis. It is also believed by some (Pooley, Deutschman) that there is a sympathetic inflammation of the optic nerve and retina. The excessive use of alcohol, of tobacco, inordinate and long-continued doses of quinine, are also among the generally ascribed causes of optic neuritis which may be finally followed by atrophy. But the stage of neuritis may have passed over before the examination by the ophthalmoscope shows that atrophy has occurred. But if one is on the lookout for neuritis optica in, for example, meningitis, hyperæmia, or inflammation, in tumors, in diseases of the mastoid process (Kipp), it will sometimes be discovered when

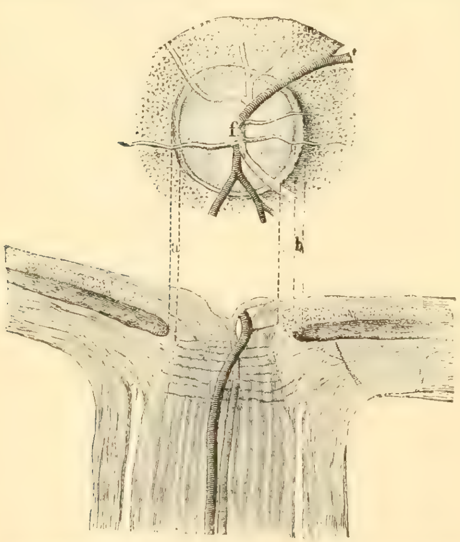

FIG. 148.—NORMAL OPTIC PAPILLA. (SCHMIDT-RIMPLER.)

scarcely suspected. Optic neuritis is called ascending or descending, according as it passes from the eye to the nerve, or from the brain to the nerve trunk.

Ophthalmoscopic Appearances.—The surface of the papilla is of a reddish color; the individual blood-vessels cannot be traced; there may be swelling of the head of the nerve, varying in degree according to the intensity of the disease; the veins are large and dark-colored or tortuous, or the whole papilla may be one mass of exudation, in which the individual parts of the nerve cannot be traced, the outlines being lost in the tissue of the retina and choroid. It is to be understood that there are all degrees of intensity of optic neuritis, varying from what may be called hyperæmia or congestion, to the swollen mass called an obstructed papilla, *Stauungspapille* (German), choked disc.

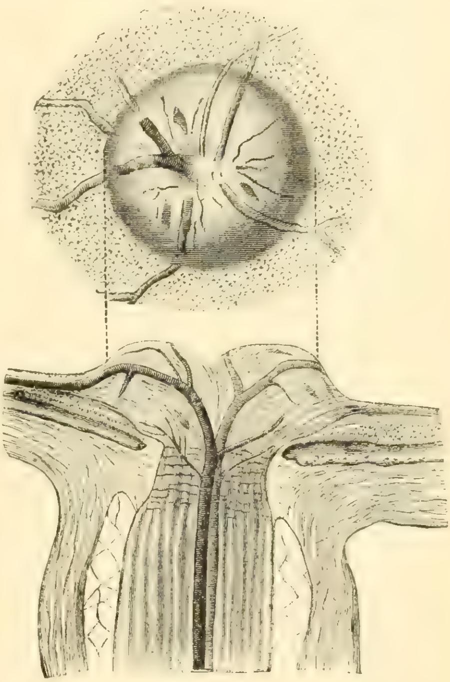

FIG. 149.—CHOKED DISC. (SCHMIDT-RIMPLER.)

Prognosis.—This depends very much upon the cause. Optic neuritis from syphilis, narcotic poisonings, alcohol and tobacco, or quinine, may be entirely or in part recovered from, while that from prolonged pressure, tumors, abscesses, and so forth, generally leads to atrophy and complete loss of sight.

Treatment.—This also depends upon the cause. Rest of the eye, with protection from bright light, abstinence from any agents that have possibly poisoned the blood, are indicated in all cases. Local blood-letting, mercurials, especially by inunction, the sweating treatment by pilocarpine, are indicated in idiopathic cases. Where syphilis is the cause of the neuritis, it is to be vigorously treated.

ATROPHY OF THE OPTIC NERVES.

Ophthalmoscopic Appearances.—The cptic papilla is of a whitish or grayish color. The arterial blood-vessels are very small. In advanced cases they have disappeared altogether; the veins may also be attenuated and the whole papilla have a *shrivelled, glistening appearance.*

Atrophy of the optic papilla, may be a result of a neuritis of active variety, such as has just been described, or it may appear, notably in syphilis, as an atrophic process, with no indications of neuritis that our present means of diagnosis enable us to detect. It has then been probably preceded by a lesion in the cerebrum. It also occurs in diseases of the brain and spinal cord. The vision is always impaired, and when the atrophic process goes on, it is obliterated. The atrophic process is, however, sometimes arrested. These are also congenital cases. There may be an anæmia of the optic papilla, sometimes mistaken for atrophy, which may be completely recovered from. The visual field is usually cut off, symmetrically in the periphery and as the disease advances the field becomes smaller and smaller. The color sense is impaired. One of the pathognomonic indications of amblyopia due to excessive use of alcohol, is the existence of a central scotoma for red.

Amaurosis is the old name for conditions which since the use of the ophthalmoscope have been found to be chiefly atrophy of the optic nerve. Amblyopia is also a name, although it is that of a symptom mainly, applied even to the present time to loss of sight due to affections of the optic nerve. For example, toxic amblyopia, or that caused by alcohol, tobacco, quinine, lead, and so forth.

TOXIC AMBLYOPIA.

Many years ago, Graefe[1] reported a few cases of retinitis, which he supposed to be due to the use of quinine. A review of these cases in the light of modern investigation, shows that they probably are not at all due to this drug, for they exhibited none of the symptoms which in late years have been plainly

[1] Archiv für Ophthalmologie, Bd. iii., II., 396.

marked out, by the consensus of several writers, as indicating quinine amblyopia. This may be said to be true, because these symptoms are invariably found in all the cases. These are: (1) great concentric limitation of the field of vision, so that the vision is telescopic; (2) lessening in the size of the arteries.

During the first period after the poisonous dose of quinine has been taken, there may be complete obliteration of the vision. A very large dose of quinine repeated sveral times is usually necessary to produce amblyopia. One of my patients, one of the very first cases reported, in which the diagnosis of amblyopia from quinine was positively made, took on a very careful estimate 480 grains in twenty-four hours.[1] An affection of the auditory nerve is sometimes associated with that of the optic nerves, so that the patient is deaf as well as blind. It should be clearly understood that there are no cases recorded, where small or even moderately large doses of quinine have produced amblyopia. Amblyopia from quinine, has been more frequently observed in America than in Europe, for the simple reason that quinine is very rarely, if ever, employed in Europe in such large doses as is quite common in America. In one case of quinine amblyopia that came under my care, and which I have fully reported,[2] the quinine was used per rectum to arrest a pernicious malarial fever. It is seen from this, that although amblyopia does occur from quinine, it is entirely exceptional and not to be compared with those forms of toxic amblyopia that may result from an habitual and excessive use of the poisoning agents.

For example, the amblyopia that occurs among those who constantly and regularly drink spirituous liquors, is not of the exceptional character of that from quinine, while the amblyopia reported from the use of iodoform as a dressing is a very rare occurrence.

There has been much loose writing about toxic amblyopia, so much so as to cause a doubt in some minds whether it is so frequently caused by alcohol and tobacco, as has been supposed; and some have doubted if amblyopia from tobacco ever occurs. As for myself, I am an agnostic as to this latter subject. I have

[1] Archives of Ophthalmology, vol. ix., No. 1, p. 81.

[2] Transactions American Ophthalmological Society, 1887.

seen amblyopia occurring in those who drank heavily, and who also used tobacco, but I am not at all sure that I have seen a case when the constant and even immoderate use of tobacco alone, has caused amblyopia. Serious harm to the general system can certainly be sometimes traced to the use of tobacco, but in New York, at least, cases of amblyopia due to this drug are extremely rare.

My late associate, Dr. Edward T. Ely,[1] examined the eyes of one hundred and two persons working in cigar factories, under generally unhygienic conditions and using tobacco to excess in smoking. He did not find one case of tobacco amblyopia, among these one hundred and two. He found some men with presbyopia and hypermetropia, who were embarrassed in doing the finer parts of their work and who might have passed for cases of amblyopia. Dr. Ely astutely remarks that, if amblyopia were a common disease among cigar makers and smokers, a certain tradition would grow up among them on this subject. But none such exists. In his inquiries among the most intelligent workmen, he did not find one, even among those grown old in the business, who had even ever heard of vision being impaired by tobacco. In only two of Dr. Ely's cases did he find evidence that the amblyopia might be attributed to tobacco, and he did not think the evidence positive. Indeed it could not be called proof. In Turkey, where everybody smokes, and smokes excessively, as has been set forth by R. B. Carter and myself and others, from most reliable evidence from physicians, amblyopia or amaurosis from tobacco is unknown. The kind of tobacco used may have something to do in explaining the discrepancy between Mr. Jonathan Hutchinson's views and those here set forth, for in London and in Great Britain, in general, the laboring classes seem to use a much stronger kind of tobacco than is used in this country and in Turkey. Yet some of Mr. Hutchinson's own countrymen are almost, if not quite, as agnostic in their views as to the existence of tobacco amblyopia, as is the present writer. Among them may be mentioned Mr. R. B. Carter and the late Sollberg Wells. Mr. Hutchinson thinks that total abstainers from stimulants, are more liable to suffer than

[1] New York Medical Journal, April, 1880.

others, and he has an impression, he says, that on the whole alcohol counteracts tobacco. Yet, as Dr. Ely points out in his paper, in at least half of the cases reported by Mr. Hutchinson, the patients were drinkers.

Treatment.—In suspected toxic amblyopia, the use of alcohol and tobacco should be entirely discontinued, and strychnia administered. It is better to employ the drug hypodermically, beginning with a very small dose, say, one one-hundred-and-twentieth of a grain, and going up slowly day by day until a physiological effect be produced. After an interim, the treatment may be resumed.

It is hardly necessary to say that no remedy will be of avail if true atrophy has occurred; but as anæmia of the optic papilla may be mistaken for atrophy, in at all doubtful cases it is well to give strychnia. Besides this, the general nutrition should be carefully looked after, and the patient kept under the best possible hygienic conditions. Most marked improvement in the vision, often results from such treatment in cases where the use of alcohol and tobacco are absolutely given up, and strychnia administered.

Ophthalmoscopic Appearances in Amblyopia Supposed to be from Alcohol and Tobacco.—In amblyopia due to these agents, the ophthalmoscopic appearances are not marked. Observers are apt to speak of the optic papilla as well as the whole fundus, as having a dirty appearance. Sometimes the papilla is markedly white, and the vessels small.

OPAQUE NERVE FIBRES.

This is a congenital condition, easily recognized by the ophthalmoscope; but those who are not on the lookout for the condition may mistake it for serious disease.

This anatomical condition is caused by a retention of the medullary sheaths, which in a normal condition are lost when the nerve expands into the papilla.

An irregular white patch of dull white opacity is seen to involve usually a small part of the periphery of the optic papilla. Vessels may sometimes be seen under it. It may affect one eye alone, or be symmetrical. It, of course, increases the size of

the blind spot, but does not impair vision unless very large. Its existence is almost always unsuspected by the patient, for the simple reason that he cannot usually compare his vision with that of others in such a way as to enable him to detect this large blind spot. (See chromo-lithograph No. XII.)

COLLOID DEGENERATION OF THE OPTIC PAPILLA.

Number eleven in the series of chromo-lithographs appended to this book, gives an accurate representation of a peculiar form of change in the optic papilla known as colloid degeneration. This condition is the result of an optic neuritis, usually of an insidious form. In some cases the first diagnosis is made when the patient is not aware of any loss of vision, but suffers from asthenopia for which glasses are desired. In one case that I saw, a lady in middle age, fifty-two, was apparently suffering from malarial poisoning, and an optic neuritis of a low grade was followed by colloid degeneration of the papilla. The vision was only moderately impaired, when the disease had run its course. R. E. = $\frac{20}{100}$; L. E. = $\frac{20}{40}$. The ophthalmoscopic appearances are those of little grayish-white masses heaped up on the surface of the papilla.

CHAPTER XXII.

GLAUCOMA—INCREASED TENSION OF THE EYEBALL.

Γλαυκος, *green*, and termination meaning *tumor*, because of the bluish, greenish, or grayish appearance of the pupil (Mackenzie).

Definition.—Objective Symptoms.—Classification.—Character of the Excavation of the Optic Papilla.—Pathological Condition of Excavation.—Ophthalmoscopic Picture.—Loring's Description.—Increased Tension.—Statistics of Age at which Glaucoma Occurs.—Priestley Smith's Tables.—Pathology of Glaucoma.—Influence of the Gouty Diathesis.—Glaucoma Caused by Mydriatics.—Chronic Glaucoma.—Differential Diagnosis between it and Atrophy of the Optic Nerve.—Etiology of Glaucoma.—Glaucoma after Extraction of Cataract.—Treatment.—Iridectomy.—Sclerotomy.—The Value of Eserine.—Periodic Glaucoma.

Here, as in other instances in ophthalmology, the name of a disease is but an expression of an obsolete pathology, or a name of a symptom, perhaps of itself not important. Glaucoma, in the professional acceptation of our time, is a disease characterized by increased tension of the eyeball. There are numerous other symptoms attached to the idea of glaucoma, which will be fully discussed in this chapter, but if increased tension be present, glaucoma may be said to exist. Glaucoma occurs in two chief varieties. First, it is an independent affection appearing in eyes that have been previously healthy (primary glaucoma). Second, it occurs in consequence of other diseases, such, for example, as keratitis, phakitis (swelling of the lens). In the latter instance, it is styled secondary glaucoma. The primary form may be further subdivided into acute and chronic glaucoma.

Primary glaucoma, as distinguished from secondary, is that form whose occurrence or existence cannot be referred to any previous disease of the eye. This is the form of chief discussion, for, in the nature of things, it is that which presents most of the symptoms which, when grouped, constitute the disease, while in secondary glaucoma the chief symptom, the increase of intra-ocular pressure, is perhaps the only one present.

The picture of acute glaucoma is a decided one. The increased tension is marked. There is, besides, limitation of the visual fields, and probably excavation of the optic papilla. But this excavation may not be seen in consequence of haziness of the cornea, and turbidity of the aqueous humor. There is also congestion of the general ocular conjunctiva and of the ciliary region, as well as lachrymation and photophobia. The pupil is dilated and the iris pushed forward, while the cornea is insensible. It is possible to bring a piece of paper or the like in contact with it, without exciting any reflex action. In such cases the accommodative power is nearly lost, and the vision is much impaired. If the fundus can be seen, the excavation of the papilla, as well as spontaneous pulsation of the arteries, is usually present. The veins are dilated and tortuous and also pulsating.

The excavation of the optic disc in glaucoma is peculiar to the disease. It is complete to the edges of the disc, and the vessels pass over the sides in an abrupt way, as shown in the col-

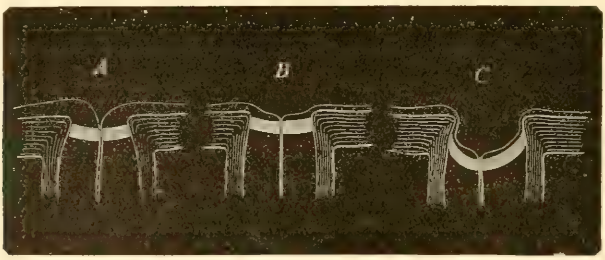

FIG. 150.—CUTS SHOWING DIFFERENT FORMS OF EXCAVATIONS OF THE OPTIC NERVE. (FUCHS.) *A*, Congenital excavation; *B*, atrophic excavation; *C*, glaucomatous excavation.

ored plate, Fig. III. In making an ophthalmoscopic examination of the excavation in glaucoma, by the indirect method, if the object-lens be moved sideways, the margin of the picture seems to move over its centre "like a frame over a picture." Besides all these objective symptoms, the patient will complain of constant neuralgic pains, extending in the course of the facial branch of the fifth nerve, and of the most excruciating character. Indeed, those who are not familiar with the characteristic phenomena of glaucoma may mistake the disease for neuralgia. This is a grave error, which generally leads to

allowing the patient to become completely blind. If all these symptoms just narrated be present, even the inexperienced surgeon would seldom, if ever, mistake glaucoma, but unfortunately they are not usually all present in one case. Yet he who remembers that increased tension of an eyeball always means glaucoma, will never mistake it for any other disease.

I am perfectly well aware of the other classifications, namely, congestive, inflammatory, simple glaucoma, and so forth, and something may be said in their favor, but, from careful observation, I am convinced that the most satisfactory nomenclature is that which groups all forms of primary glaucoma under two heads, acute and chronic, as has been done here. It should be said, in addition, that not all the cases of acute glaucoma, that is to say, those attended with great pain and congestion in the ciliary region, are also accompanied by the marked excavation of the optic papilla, which has been described, but should the attacks recur frequently, the excavation finally appears.

In chronic glaucoma, in the intervals of acute or subacute attacks, when the intra-ocular pressure is not increased, we are obliged to depend upon two important conditions to enable us to make a diagnosis between atrophy of the optic nerve, and chronic glaucoma. These conditions are, first, the visual field. The visual field in atrophy is generally symmetrically contracted, while that in glaucoma is contracted unevenly, more to the nasal side. This is an important indication, but if it do not exist in conjunction with the other, it is deprived of some of its significance. It is, however, in the character of the excavation, in the absence of increased tension, that we make the diagnosis in such cases. This excavation (glaucoma) is complete in all the parts of the optic papilla. To use one of the old similes in description, the vessels climb over its edges as if out of a kettle. The foregoing figures from Fuchs, as well as the chromo-lithograph, illustrate this. It is remarkable that in the early discussion of this disease, with the light of the recently invented ophthalmoscope, such observers as Jaeger should have considered that which is now so readily recognized as an excavation, to be a swelling.

Loring[1] observes that in the earlier stages of glaucoma, it

[1] "Text-Book of Ophthalmoscopy," vol. ii., p. 227 *et seq.*

may happen that the excavation does not extend all about, but exists on one side, usually, not always, on the temporal side. This author considers it difficult to say positively whether such an excavation be a commencing glaucomatous excavation or a physiological one, that is being transformed into a glaucomatous one. In the intra-ocular pressure the lamina cribrosa is pushed backward. In the earlier stages, the anterior portion is first moved, while the posterior border retains its original position. Subsequently, the latter also gives way, and the tissue in front of the lamina is absorbed until it exists only as a membranous expansion at the bottom of the papilla.[1]

Loring believes that it is the implication of the lamina cribrosa, and the changes that it undergoes, that chiefly distinguish a glaucomatous from a physiological or atrophic excavation, in which the lamina retains its normal place. An excavation of glaucomatous type may be from one to nearly two millimetres. Of the ophthalmoscopic picture Loring remarks "that the pale-blue color,[2] or the pale or emerald-green color of the rim, especially on the temporal side, comes into view with a low grade of illumination. With the now common illumination from a frosted electric light of 16-candle power, this effect can be very much better seen than with a lamp or gas-burner.

The choroid has a part in the ophthalmoscopic picture. The white ring around the nerve is due to atrophy of the choroid. This ring is of varying width, while the whole choroid has a faded, washed-out appearance (Loring). The vitreous opacities, if they exist, as some authorities claim, are certainly not marked in chronic glaucoma, and can only be seen by very close examination. As in atrophy of the optic nerve, it is somewhat of a characteristic of glaucoma that they do not occur, although Loring argues that we might naturally conclude that they are present, as in all affections of the uvea, but in glaucoma the character of the uveal inflammation is rather that of a swelling than an exudation, that does not, after all, naturally lead to hyalitis.

To note a suspected glaucomatous excavation, the direct method of ophthalmoscopic examination is the one to be em-

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[1] Loring, *loc. cit.*, p. 228. [2] *Loc. cit.*, p. 232.

ployed, for one is less likely to make an error of overlooking an incipient excavation. Yet the inverted aerial image should not be entirely given up, as is too much the custom. Loring considers the picture by the reversed method, as clearer and brighter, and he thinks that slight pulsations, whether spontaneous or artificial, are more easily detected from the concentration and brilliancy of the picture.

The degree of hardness of the globe varies somewhat in health, according as the sclerotica is more or less elastic, but yet there is a normal resistance which can only be determined by frequent testing, and which cannot be perfectly described. The surgeon should accustom himself, by testing normal eyes, to determine whether or not the tension is increased in a given case. While it may be considered as about the same in all normal eyes, it varies in diseased ones all the way from extreme softness to stony hardness. To test the tension of an eyeball, the patient is directed to close his eyes gently, and to look downward. The surgeon then places both forefingers upon the upper part of the globe, and makes pressure and counter-pressure, much as in testing for fluctuation in the case of suspected abscess or the presence of fluids. The two eyes of the same patient should always be carefully compared. Bowman (London, 1860–82) made a system for recording the tension as follows:

Normal tension, Tn.

T+1, T+2, T+3 for successive degrees of increased tension. T−1, T−2, T−3 for degrees of decreased tension. A sign of interrogation in case of doubt.

While this system of nomenclature is of some value, it is usually sufficient to note that the tension is increased or diminished.

SYMPTOMS OF ACUTE GLAUCOMA.

The symptoms of glaucoma of an acute type, may be enumerated as follows:

Objective:

1. Increase of tension.
2. Ciliary and conjunctival congestion.
3. Anæsthesia of the cornea.
4. General contraction of the visual field, usually more to the nasal side.

5. Haziness of the cornea.
6. Turbidity of the aqueous humor.
7. Total excavation of the optic papilla.

Subjective:

1. Pain of a neuralgic and sometimes intermittent character.
2. Halo around a lighted object.
3. Impairment of vision and of accommodation.

In the prodromal stages of glaucoma, a dull, heavy pain in the forehead is also spoken of. The haziness of the cornea is due to œdema, as shown by Arlt. It is more marked in the centre of the cornea. Fuchs shows that one may demonstrate the cause of the halo by looking out upon a street light on a winter's evening, through a frosted pane of glass. Fuchs [1] adduces the rapid clearing up of the cornea after paracentesis or iridectomy as well as the anatomical examination as proof of this. This latter shows that the most anterior lamellæ of the cornea are separated from each other by fluid. According to this author, the fluid is also found in the shape of minute drops between Bowman's membrane and the epithelium, and between the epithelial cells themselves. These are thus separated from each other on pressure upward, so that the surface of the cornea becomes early uneven and dull. If the lifting up of the epithelium goes on to any great extent, little vesicles appear on the surface of the cornea.

But, as has been said, acute glaucoma, which no educated physician ought to mistake, is by no means often seen with all these phenomena, which have thus been detailed. Even acute glaucoma admits of many varieties in the severity and number of the symptoms. We may see a case of glaucoma, with only moderate attacks of pain, which quickly pass over, and with very slight congestion of the conjunctiva and ciliary body, and with scarcely any dilatation of the pupil or anæsthesia of the cornea, but we may safely say, that there are no cases of acute glaucoma, in which there is not impairment of vision and failure of accommodation, with limitation of the visual field and above all increase of tension.

Unfortunately for the patient, many cases of acute glaucoma

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[1] "Lehrbuch," p. 377.

pass over without a diagnosis, especially among the ignorant classes, or among those who, although not ignorant, despise medical authority and ignore all disease until actually overcome and disabled permanently by it. Among such people one attack succeeds another. It is treated, if treated at all, as neuralgia of the eye and face, until the havoc made by each attack, in a gradually restricted field of vision, impairment of visual power, excavation of the optic-nerve entrance, finally culminates in a rigid and widely dilated pupil, an atrophied optic nerve, a stony-hard globe, and complete loss of sight—*absolute glaucoma.* At last opacity of the lens, *secondary cataract,* completes the picture, and we have visual ruin, to which is sometimes added a persistent aching pain, which can only be relieved by enucleating the sightless eyeball.

AGE AT WHICH THE DISEASE OCCURS.—Acute glaucoma is predominantly a disease of the middle-aged and old. Of 31 successive cases in my private practice (see table), four only occurred in persons under forty years of age. That of the youngest case had a large hysterical element. Mackenzie thought that it never occurred in young persons. Some observers have thought that the Jewish race is particularly disposed to glaucoma, but I have not been able to verify or disprove this opinion.

Below are given the ages of thirty-one patients having glaucoma, whom I have seen in private practice:

22	52	57	64	70
26	54	57	64	71
36	54	60	65	74
39	55	60	65	77
41	56	63	69	79
49	56	63	70	82
50				

Eleven of these were males, 20 females.

The following cases are taken from the practice of the Manhattan Eye and Ear Hospital:

1 male	25	1 female	34	2 females	38
1 female	27	1 female	35	3 males	38
2 females	28	1 male	35	1 male	39
1 female	30	2 males	36	5 males	40
1 male	31	1 female	36	3 females	40
1 female	33	2 females	37	1 female	41

4 females............42	6 females............53	3 males..............65
2 males..............42	3 males..............53	4 females............66
2 females............43	6 females............54	5 females............67
2 males..............43	2 males..............54	2 males..............67
1 female... 44	4 females............55	2 females............68
6 females............45	3 males..............55	3 males..............68
2 males..............45	1 female.............56	2 males..............69
1 male...............46	6 females............57	3 males..............70
1 female.............46	3 males..............57	2 females............70
1 male...............47	3 females............58	3 females............72
1 female.............47	1 male...............59	3 males..............72
1 female.............48	8 females............60	2 males..............73
1 male...............48	12 males.............60	1 female.............74
2 females............49	3 females............61	1 male...............75
1 male...............49	1 female.............62	1 male...............77
12 females...........50	1 male...............62	1 male...............78
3 males..............50	3 females............63	1 male...............79
5 females............51	3 males..............63	1 female.............83
6 females............52	2 males..............64	A total of 119 females
3 males..............52	3 females............65	and 82 males = 201.

It will be observed that only fifteen of these two hundred and one cases were under forty years of age.

Priestley Smith's tables of primary glaucoma, collected by various observers,[1] show a total of 431 males to 569 females. His chart indicates the ages between fifty and seventy years as those in which glaucoma is likely to occur. This corresponds very well with the tables here printed.

Not one per cent of the thousand cases thus collected began earlier than the twentieth year, while the frequency increases between fifty and seventy years. After the latter period it decreases. Cases beginning after fifty years of age are twice as numerous as those before fifty years is reached. It is very likely, from what I have seen, that Priestley Smith is correct in believing that the decrease after seventy years of age is more apparent than real, for the simple reason that among certain classes, infirmities and diseases that come to those advanced in life are considered as a matter of fate, and with Arabic tranquillity the friends and even the sufferers themselves often submit to blindness as inevitable, as being without any prospect of relief. Besides, as the author I am quoting says, they are

[1] Transactions of the Ophthalmological Society of the United Kingdom, 1886, p. 294 *et seq.*

often inmates of work-houses, or from the infirmities of age are prisoners at home.

ETIOLOGY.

For the present state of our knowledge as to the anatomical causes or rather the pathology of glaucoma, we are chiefly indebted to the investigations of Brailey and Priestley Smith, who found in the lessening of space around the ciliary processes for the performance of their secretory functions, the chief cause of the occurrence of glaucoma. The underlying cause of glaucoma, the latter-named author affirmed to be an insufficient space about the lens. This deficiency may probably occur from the following reasons:

I. Possibly from an abnormally large lens.

II. From an abnormally small ciliary region.

III. An abnormal enlargement of the ciliary processes. Priestley Smith accounts for the greater frequency of glaucoma in hypermetropic eyes by its subnormal dimensions. This, of course, can only be true of hypermetropia of a very considerable degree.

The immunity from glaucoma in young persons, is explained by Priestley Smith as due to the relatively small size of the lens in youth, which leaves ample room for "individual variations in structure, for the expansion of the ciliary process, and for the play of the iris." Hence, the things that induce glaucoma in later life, for example, violent emotion, exhaustion, neuralgia, cerebral congestion, the use of atropine, are inoperative in youth, because the predisposing condition is absent. The difference presented by the two sexes appears in my tables, as well as those of the other writers. Priestley Smith thinks the non-congestive (chronic) form occurs just about as frequently in the two sexes, while women are more apt than men to the acute form. He rejects Stellwag's theory of the rigidity of the sclera, as being the great predisposing cause of glaucoma, for he shows that even in the elastic tissues of young eyes, secondary glaucoma of several kinds occurs. He does admit the effects of a rigid sclera, as opposed to an elastic one, by noting the fact that a pressure that will excite no influence upon the eye of age, distends a youthful eye excessively in the course of a few months.

I adopt Priestley Smith's nomenclature of "congestive" in place of "inflammatory," for, as he says with unassailable force, the disease is no more inflammatory than strangulated hernia. He quotes Sir William Bowman, who wrote twenty-five years ago: "Glaucoma is in its essence not an inflammation, and when inflammatory it is only so as it were by accident or complication."[1]

Yet I believe it still simpler to divide the two chief forms into acute and chronic, while we understand that the acute form is congestive, rather than inflammatory.

Much stress is laid by many upon a gouty diathesis, as giving occasion to glaucoma. This was the view of the older authors, and it has been of late revived in this country by Richey[2] and others. There is some ground for such an etiology, for there are cases in which the rheumatic or gouty diathesis is well marked, and in which anti-rheumatic constitutional treatment of the usual kind is of avail. But, on the other hand, I have seen cases in which no rheumatic or arthritic diathesis could be demonstrated or fairly suspected to exist.

Local inflammations of the eye, as we have seen, phakitis, swelling of the lens, may produce secondary glaucoma. It is possible that an uncorrected error of refraction may produce glaucoma. Such a theory is very tenable, but it would be difficult to show that the existence of astigmatism was not a mere coincidence and not a determining cause. It was long since shown that the instillation of atropia may bring on an attack of glaucoma (Hasket Derby). The danger of using atropine is because the filtration angle may be already on the verge of dangerous compression, and the thickening produced in the base of the iris when the pupil dilates, may at once cause an actual obstruction. But unless scopolamine should prove to be one, there is no mydriatic that may not produce glaucoma, and there is none, scopolamine included, which does not produce constitutional effects. Scopolamine dilates the pupil more widely than any mydriatic which I know. If it be true that it does not cause glaucoma, it may be because it leaves a larger space between the ciliary process and the lens.

[1] Trans. Ophthalmological Society of the United Kingdom, 1886, p. 294 *et seq.*
[2] Transactions American Ophthalmological Society, 1892.

Dr. John Green reports[1] a case of acute glaucoma following closely upon a single application of a two-per-cent preparation of duboisia. The case was that of a woman of sixty-seven, who had lost one eye from acute glaucoma. When she called on Dr. Green, her vision had been failing in the other eye for more than a year, but she had no pain. Her vision was $\frac{16}{80}$, pupil not at all dilated, anterior chamber shallow, tension +? Dr. Green dilated the pupil by means of a slip of paper impregnated with duboisia extract. With the ophthalmoscope he found a depression of the outer half of the optic disc, with the lamina cribrosa plainly visible through the transparent floor of the excavation. Two hours after extreme pain came on, and continued, attended with nausea and vomiting. The next day she had all the symptoms of acute glaucoma. Under the use of calabar extract and pilocarpine, the pain, dilatation of the pupil, cloudiness of the media diminished, and vision promptly improved. Finally her vision, about a week after, returned to its normal condition. One month after it began to fail again, and in October glaucoma had fully set in.

Doubt is sometimes expressed,[2] whether the occurrence of acute glaucoma is not coexistent with the use of certain remedies, rather than caused by them. This may be true in a very few cases, but the evidence is overwhelming that atropia may cause an outbreak of glaucoma.

Acute glaucoma occurring very suddenly, without warning, like thunder from a clear sky, is called *glaucoma fulminans*, and glaucoma that has run its course to complete blindness, with the long chain of symptoms that have been enumerated, is called *glaucoma absolutum*. Hemorrhagic glaucoma, is also a sub-classification, but, after all, if we divide glaucoma, as has been here done, into primary and secondary, and then into acute and chronic, there will be a sufficient comprehension of the various forms for the thorough understanding of the subject by the student.

CHRONIC GLAUCOMA.

Chronic glaucoma is a disease which may be readily mistaken for atrophy of the optic nerve. In some cases even experts may differ as to the diagnosis. Yet certain features may

[1] Transactions of the American Ophthalmological Society, 1880, p. 148.
[2] Dr. Wadsworth, *loc. cit.*

be agreed upon, as distinguishing it clearly from slowly progressing atrophy. These symptoms should be held distinctly in mind, for while an operation on the iris may arrest for a time the advance of chronic glaucoma, and eserine also may be of service, neither they nor any other known remedies will be of any value in well-advanced and advancing atrophy of the optic nerves.

Increased tension is in chronic glaucoma, as in acute, the distinguishing mark of the presence of the disease. Some writers have assumed that there is a form of glaucoma without increase of tension. It has been argued that such eyes were congenitally of an abnormally low degree of tension, and that increased tension in them, has only brought them up to what would be, in ordinary eyes, a normal degree. But this seems to me a theory with no substantiating basis. I have never met with eyes, otherwise healthy, having an abnormally low tension. It seems to me that some of them would have been encountered in my hospital service, if not in my private practice, did they occur.

THE EXCAVATION OF THE OPTIC PAPILLA.—Here there is room for difference of opinion, but inasmuch as without in-

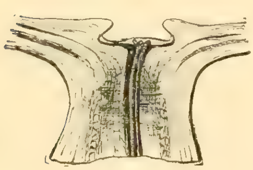

FIG. 151.

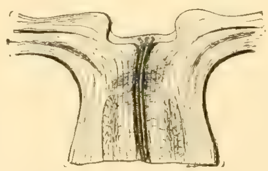

FIG. 152.

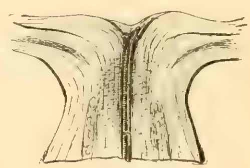

FIG. 153.

FIGS. 151-153.—GLAUCOMATOUS EXCAVATIONS. (LORING, Vol. 2, p. 229.)

creased tension there can be no glaucoma, discussion as to the differentiation of an excavation from atrophy and that from chronic glaucoma, is unnecessary. The limitation of the visual field is characteristic. In glaucoma it is more to the nasal side, while in atrophy it is generally symmetrical.

The accompanying field of vision is that of a case of chronic glaucoma, occurring in a man of fifty-one years of age. An outline of the case is here given.

X. A., age 51.

History.—The patient says that last January his right eye be-

came so painful he had to walk the floor through the night. It also was very red. It was sore six days. Saw rings around lights. Says the sight seemed to be good after that. The sight has been failing for nine weeks, and he thought his glasses only were at fault.

Present Condition.—The pupils of both eyes are slightly dilated, that of the right slightly oval. Anterior chamber of each eye shal-

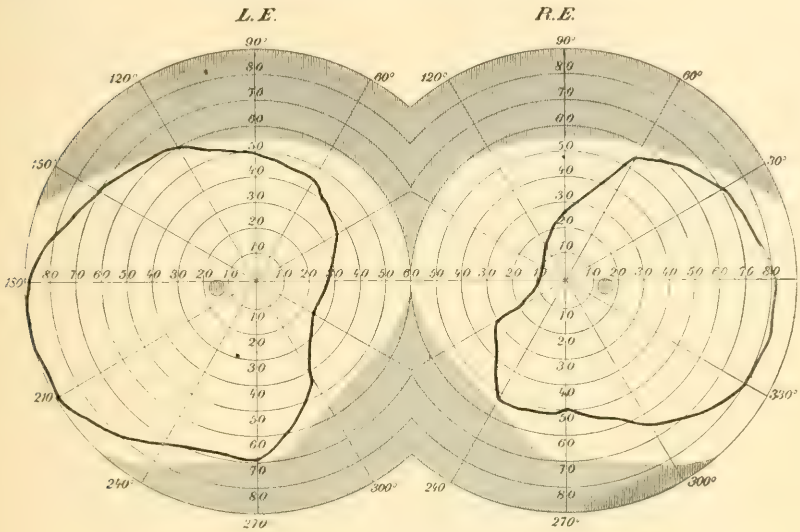

FIG. 154.

low. There is a slight greenish tinge on looking into the pupil. The tension of the right about + ½ to 1. Left + 1 to 1½. The field is contracted, especially on the temporal side.

The ophthalmoscope shows clear media, with well-marked cupping of the discs and breaking of vessels.

Operation, October 15th.—After cocainizing and cleansing the eyes with boric acid solution, double iridectomy was performed. The iridectomies were upward.

October 17th.—Bandage removed for the first time, eyes cleansed and conjunctiva found white. Cotton and drop shade applied. Has no pain.

October 18th.—There is slight leakage from right.

October 20th.—Bandaged right. Left open. Eserine, gr. ss. to ℥ i., dropped in.

October 21st.—Has no pain, some lachrymation.

October 24th.—Doing well.

October 25th.—Right counts fingers. Left $\frac{20}{70}$, has no pain, doing very nicely.

October 28th.—R.V. $= \frac{3}{200}$. No improvement. L. V. $= \frac{20}{40}$: $\frac{20}{20}$ w. + 75 D. No astigmatism. J. No. 1 8″ to 18″ w. + 2.75.

Discharged.

The accompanying chart is made from the visual fields of a patient, male, in his 57th year. R. V. $= \frac{20}{100}$ − ; L. E. $\frac{20}{50}$ −. An irid-

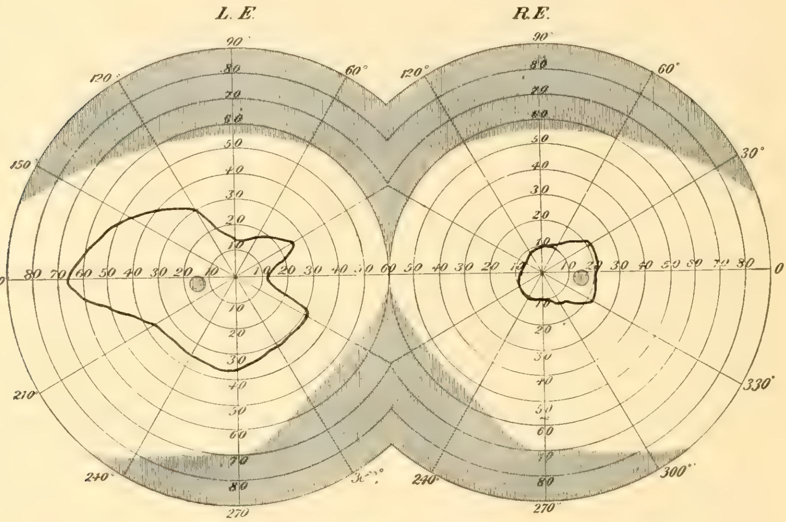

Fig. 155.

ectomy was performed by Dr. Miller of Providence, R. I., and the patient retains his vision.

The next is the field of the left eye of a woman of about 45, who has lost the right eye from chronic glaucoma, and for who mafter use of eserine for ten years, I performed an iridectomy. The disease had been arrested for six months.

Chronic glaucoma may pursue its course in one eye, leaving the other unaffected even to advanced life, and while it is the rule that glaucoma in one eye, is to be followed by the same disease in the other, it is not a rule without many exceptions, as some interesting examples show. This is a matter of the greatest importance in making a prognosis. Besides ulcerative keratitis, advancing corneal staphylomata and posterior synechiæ may cause secondary glaucoma. But here the diagnosis need involve no particular difficulty, if the surgeon in treating these

conditions is on the lookout for a hard globe. Glaucoma may coexist with ordinary senile cataract. I was consulted some years ago by a physician of advanced years, he being more than eighty years of age, on account of impairment of sight in one eye. I then learned that the sight had been completely gone in the fellow for some time. On examination, I found that there was chronic glaucoma, with absolute loss of vision. It is rather remarkable that the old gentleman recovered his

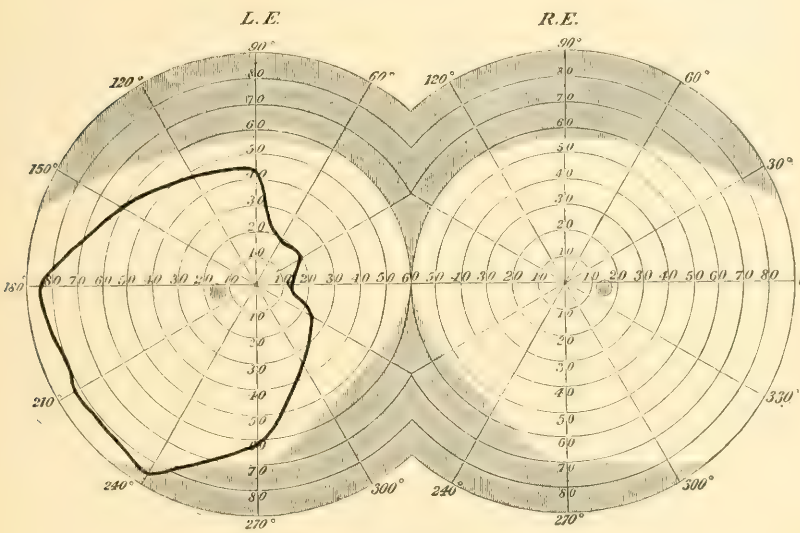

FIG. 156.

sight in the eye suffering from hemorrhagic retinitis, so that he was able to use it for reading and writing, and he lived some four years after the attack.

SECONDARY GLAUCOMA.

Glaucoma sometimes occurs after a cataract operation. This most untoward of results generally is due, according to our ideas of the etiology of the disease, to incarceration of the iris in the wound, a gluing together of the capsule and the iris, and an interference, by inflammatory exudation in the anterior part of the eye, with proper filtration; in other words, to lessening of the space between the ciliary processes and the lens. The increased

tension, diminution of vision, very deep anterior chamber, are the symptoms calling attention to it.

Dr. Buller[1] reports three cases where glaucoma occurred after extraction of cataract.

In the first case, the inner angle of the wound contained just a small portion of entangled iris, enough to show a small dark spot beneath the conjunctiva. Sixty days after the extraction the eye was quiet, and vision $\frac{20}{50}$, with rather a dense capsule. Discission was performed with two needles. The eye secured $\frac{20}{30}$ vision and it was freely used for several years. Five years after an atrophic appearance of the optic nerve, just as in ordinary chronic glaucoma, appeared, with increased tension. The vision soon became reduced to $\frac{20}{200}$, and sclerotomy was performed without benefit. The eye was lost. Later the other eye was operated on, and a good result followed. Dr. Buller thinks that the small portion of entangled iris in this case was one factor, the patient's excessive use of his eyes another, and the thick capsule the third in producing the glaucoma. I believe that the patient might have had this disease without any of the pathological conditions, if he used his eyes excessively.

In Dr. Buller's second case, the eye was quiet seventeen days after the operation, with a vision of $\frac{6}{60}$. There was some thick and wrinkled capsule remaining. A capsulotomy was performed, and repeated a year after, and in two years, or four years and three months after the original operation, his vision was reduced to perception of light; the tension was +. A sclerotomy was performed, but without benefit, and the eye was lost. This same patient lost the second eye from the same disease. A delicate-looking, shining capsule was stretched across the pupil, but without the adhesion of any iris. He was advised not to use his eyes, but he did so, reading the evening papers at night, and glaucoma occurred, but under eserine it disappeared.

In both of Dr. Buller's cases the observations of Mr. Collins are confirmed. These are quoted in the chapter on Cataract. He describes this condition as an almost constant pathological state, that is to say, the occurrence of a dense capsule, the upper portion of which evidently rests in contact with the corresponding filtration region. It is, however, to be remarked that in Dr. Buller's cases excessive use of the eyes has been an important factor in the development of glaucoma. We can hardly warn our patients sufficiently against such use for a long time after a successful operation.

[1] Transactions of the American Ophthalmological Society, 1891.

I have seen and operated upon a few cases of cataract in which secondary glaucoma occurred.

Extraction of the lens in these cases proved to be curative of the glaucoma, as well as of the cataract. Two of them have been observed for several years, and no return of the glaucoma has occurred, while the third has now remained for a year, without reappearance or breaking out of glaucoma.

TREATMENT.

It may be truly said that all our therapeutic knowledge of glaucoma is derived from the clinical investigations of A. von Graefe, which finally led to his performance of an iridectomy upon a Berlin shoemaker, who lived many years after with good eyesight, as a living monument to the wisdom and skill of this illustrious man. What Helmholtz did for the examination of the fundus oculi, and Donders for the correction of faulty refraction of the eye, that Graefe did in his clinical and pathological researches as to the nature of glaucoma, and the means for its relief. After the lapse of nearly forty years, iridectomy remains our best resource for the relief of acute glaucoma, and it continues to afford permanent relief to a large percentage of cases. Every ophthalmologist in his own experience, knows of many cases of useful and even eminent people rejoicing in vision, which is the direct result of Graefe's operation of iridectomy.

In acute glaucoma, or in subacute, this operation should be performed without an hour's delay. The incision should be made more peripheral than that for artificial pupil, so as to divide the iris well into the ciliary border. The fellow-eye should never be bandaged after the operation upon the glaucomatous one. As Arlt demonstrated, this precaution often saves the patient from an attack of glaucoma on the fellow-eye.

Mr. McHardy brought forward the subject of removal of the lens in its capsule for the cure of glaucoma, and performed the operation and saved an eye.

These are cases in which iridectomy, although carefully performed, has failed to lower the tension, and consequently to produce a curative effect. I should not hesitate, then, in these cases of pernicious glaucoma, to go on and remove the lens.

Prognosis.—The prognosis is good after this operation in

those cases in which acute glaucoma has made its first outbreak. If the attacks have been frequent, and advanced structural changes have occurred, such as deep cupping of the optic disc, great anæsthesia of the cornea, this much cannot be said. The tension, although temporarily reduced to normal, will again become increased, and the disease advance to glaucoma absolutum. In such cases, that is to say, cases in which the visual field is greatly reduced, and the excavation of the optic papilla is deep, and the tension remains increased, removal of the lens offers some prospect of permanent arrest of the morbid process. I am led to this view from the few but striking cases of glaucoma, coincident with senile cataract, in which I have had perfect relief after the operation of extraction of the lens.

In chronic glaucoma, insidiously and steadily advancing, iridectomy offers so little, that I am always willing to temporize with the instillation of eserine, as long as it keeps the tension of the eyeball to a normal standard, and the accommodation and vision are not failing. Even in mild, subacute cases of glaucoma, the instillation of eserine may subdue an attack and postpone an iridectomy. But if even these mild attacks continue to occur, no delay should be had, but the iris should be excised at once.

Sclerotomy, an incision through the sclera, somewhat as in a section for cataract, except that the section is not completed, a bridge of tissue being left, has proven a failure as a substitute for iridectomy, and need not be considered by the surgeon who has to deal with a case of glaucoma requiring operation. Repeated paracentesis, a means of treatment timidly suggested by Mackenzie, and revived by Sperino (Italy, nineteenth century), need not be seriously considered. Graefe's operation of iridectomy remains to-day the only operation for glaucoma. The manner in which iridectomy acts in promoting a cure, still remains a mystery. When the operation was first suggested and performed in New York, a distinguished general surgeon remarked, in a public medical lecture, that it was theoretically as sensible as would be the cutting out a piece of the peritoneum to cure peritonitis, but he probably had not studied the nature of glaucoma as carefully as had Graefe. We must, however, admit that the explanation of the means by which

iridectomy effected a cure was never satisfactory until our own time. We may now believe that it is chiefly curative because it lessens the difficulty of filtration from the eye, and the dangers of over-distention of the ciliary region. It increases the iridic angle, and it unloads the blood-vessels of the ciliary body.

In many instances the operation reduces the tension at once and permanently. Some have thought this due to the yielding cicatrix which results from the operation. Certain it is, that this is one of the results attained. In the membrana tympani is a triangular spot of tissue, Shrapnell's membrane, which serves the good physiological purpose, by its greater yielding capacity, of often saving the drumhead from undue distention and subsequent rupture. It is possible, as Stellwag suggests, that this is the curative action of a well-placed peripheric iridectomy. Argyll Robertson (Edinburgh) recommends trephining the cornea, in cases such as I advocate the extraction of the lens.

Horner's statistics of the results of iridectomy show, what every careful observer has experienced, that it is a much more successful operation in acute than in chronic glaucoma. 12.5 per cent of cases of congestive or inflammatory glaucoma are improved, 11.5 per cent remain the same. 10 per cent retain some vision, while only 6 per cent ultimately lose their sight. Of simple glaucoma, only 22.32 per cent are improved, 37 remain the same as before the operation, 23 recover some vision, while 17.7 per cent lose their sight in spite of the operation. In hemorrhagic glaucoma, or, more properly, glaucoma supervening upon hemorrhagic retinitis, iridectomy may temporarily arrest the process, but usually only in this way. But in these cases, the glaucoma is secondary to the retinitis, just as much as it may be in keratitis, and phakitis, or certain forms of irido-choroiditis. Iridectomy in secondary glaucoma in the course of keratitis, or swelling of the lens, usually offers a sure means of relief. In secondary glaucoma occurring from old recurring irido-choroiditis, iridectomy usually offers very little. In studying such cases, we get a good clinical idea of the essential difference between irido-choroiditis and glaucoma. The former is an exudative inflammation, gluing, as it were, many of the parts of the eye together, the iris to the capsule of the lens,

for example, while the latter is essentially a swelling of the ciliary parts of the eye.

Eserine.—The use of eserine in glaucoma, is possibly unduly extolled in some quarters, and too much depreciated in others. It remains, I believe, an efficient means of continuing the visual power in many cases, until the disease may cease to advance. Unfortunately, this is not always the case, and inasmuch as the prolonged use of eserine, has the effect of inflaming the tissue of the iris, the surgeon should be careful how he puts it in the patient's hands, to be used without frequent recourse to him, to see whether or not its usefulness be not gone and an operation necessary. I have observed in operating upon cases in which eserine has been used for a considerable time, even at intervals, that the iris tissue has become very atrophied and rotten, and possibly this was the result of the eserine, knowing, as we do, that it may and does excite iritis. Were the effects of an operation in chronic glaucoma more positive or certain, we might forego the use of eserine altogether. Although it will not usually permanently arrest glaucoma, it is very serviceable in many cases, with the qualifications suggested above.

A solution of one grain to the ounce is usually as strong as should be used. Much weaker ones are often of service. The preparation becomes inert after a few weeks. It should, therefore, be frequently renewed, and kept in a dark place. It should be applied every three hours, or even oftener in urgent cases. If, for any special reason, iridectomy must be deferred, paracentesis of the cornea may be performed until the arrangements can be made for the performance of the major operation.

Glaucomatous eyes are usually hyperopic in refraction, although in a certain small proportion the refraction is myopic. Astigmatism is very likely to exist, whether coincidentally or in a causal way, I am not able to determine, but I lean strongly to the opinion that uncorrected astigmatism may have something to do with the causation of glaucoma.

Glaucoma is a disease which is likely to give good warning of the approach of an attack of the acute form. It is in itself a suspicious circumstance when a middle-aged or aged person, especially one with a gouty or rheumatic diathesis, suffers from rapidly advancing presbyopia or failure of accommodation, sud-

denly occurring. If, added to this, there are periodic obscurations of vision, and halos around lights, we may know that we have the threatenings, the *prodromata*, of acute glaucoma. The vision appears misty to some patients, and on looking at a point or object of light, like a gas-jet or a lamp-flame, it is seen surrounded by a colorless circle, which is in its turn encircled by a colored halo.

Such attacks may occur after great mental or physical fatigue, at greater or less intervals. Patients with chronic glaucoma, who suffer from acute attacks, know also when the eyeball is hard, as they sometimes say they feel it hardening, and thus know when to use eserine.

Donders showed that the halos seen by glaucomatous patients, are due to the diffraction of the rays of light passing into the eye, and that this diffraction is caused chiefly by the opacities of the cornea. He proved this by covering the lower half of the pupil, when he found that the outer and upper and lower and inner quadrants of the halo disappeared, while on covering the other half, the other quadrants disappear. It is to be remarked that halos around lights, may appear in certain cases of conjunctivitis from the diffraction of conjunctival secretion lying upon the cornea. On clearing such eyes, the halos will of course disappear. The obscurations of vision depend upon the opacities of the cornea, combined with changes in the aqueous humor.

The following case illustrates the value of eserine in glaucoma, as well as some of the innumerable phases of the disease, and also indicates the fact that heredity plays a considerable part:

Captain J. C. X. consulted me on January 11th, 1888. He was sent by Dr. Shufeldt. He was then forty-three years of age. He said that at the age of thirty-three years he noticed that there was a haze and colored rings around the light at times. Lately these symptoms have been pretty regular in appearance,—once in two months. He is a sailor, occupied on Lake Ontario. His mother had glaucoma and was operated on. His father was very hyperopic, as was his mother. His eyes pain and blur after continued use, but he soon gets better. Although only forty-three years of age, he has a large *arcus senilis* in each eye. He has opacities on each cornea.

His vision, with correcting glasses, is $\frac{20}{50}$ with each eye, and he can read No. 1 Jaeger fluently. At this moment his visual fields are normal, but he is no more free of glaucoma, for, in addition to the other symptoms, his eyeballs get hard at certain times. He was obliged to leave his occupation on the lake, of sailing vessels, in 1892, and is now a commercial traveller. On the 23d of April, 1892, having had no treatment, his vision in the right eye is $\frac{20}{50}$, left $\frac{20}{70}$, tension normal. He can read fine type without glasses. Eighteen months afterward, on November 10th, 1893, he came to my office, saying he had had attacks of late in his left eye. The vision in that eye was reduced to $\frac{20}{100}$, and the eyeball was hard. The left eye remained $\frac{20}{50}+$. I ordered him to use a drop of 1 gr. solution of eserine. He went to the apothecary's to get it, and before it was put in his eye, about half an hour from the time of my prescribing it, he says his symptoms had vanished. At any rate, the next morning his vision was $\frac{20}{70}+$, and the tension normal. While my associate, Dr. Emerson, was examining the field of vision a few minutes after, the right eye began to get hard.

This is a case which must, of course, be kept under the closest observation, but I shall not subject him to an operation, until the symptoms persist for twenty-four hours, in spite of the use of eserine, so doubtful am I, that it is of permanent service in chronic glaucoma.

The varying type of glaucoma is well shown by such cases, and yet if the observer keep in mind increase of the intra-ocular tension, as the one symptom that distinguishes glaucoma from any other disease, he can make no mistake that will prevent him from promptly recognizing the condition with which he has to deal.

CHAPTER XXIII.

DISEASES AND INJURIES OF THE CRYSTALLINE LENS—CATARACT.

(Κατα, downward ; ρασσειν, to push.)

Definition.—Origin of the Name.—Cause of Cataract.—Becker's Pathology of the Disease.—Brisseau, the Discoverer of the True Nature of Cataract.—Frequency of the Disease in Various Countries.—Different Forms of Cataract.—Congenital Cataract.—Zonular Cataract.—Anterior and Posterior Polar Cataracts.—Total Congenital Secondary Cataract.—Opacities of the Capsule.—Senile Cataract.—The Diagnosis of Opacities of the Lens in General.—The Opacity of the Lens after Glaucoma.—Nystagmus and Strabismus in Congenital Cataract.—Erroneous Ideas as to the Cure of Senile Cataracts.—Over-ripe Cataracts.—Traumatic Opacities of the Lens.—Foerster's Method of Ripening Cataract.—Pooley's Method.—Kalish's Method of Producing Absorption.—Causes of Traumatic Cataract.—Cases of Cataract following a Stroke of Lightning.—Treatment of Senile Cataract.—Simple Extraction.—Nervous and Excitable Patients.—After-Treatment.—Time of First Opening the Eye After an Operation.—Protective Apparatus.—When Glasses Should be Ordered.—Time of Operation.—Should Two Eyes be Operated Upon at the Same Time.—The Results.—Treatment of Incarcerated Iris.—Membranes in the Pupil.—Effects of Constitutional Conditions.—The Temperature after Operations.—Operation for Soft Cataract and Shrivelled Lenses, with Thickened Capsules.

DEFINITION.—*Cataract is any opacity of the crystalline lens or its capsule.*

The name is evidently derived from the old idea of a veil, or other obstruction to light, falling down or being pushed down in front of the eye. Although it contains no definition of the pathology of opacities of the lens, nor an accurate account of the nature of the disease, it is probably impossible to substitute another for it, so firmly it is fixed in the nomenclature of medicine. Cataract is caused by some interference with the nutrition of the lens, which, as we have seen, is nourished solely by drinking in nutriment from the uveal tract, and from the aqueous and vitreous humors, having no blood-supply of its own. Cataract is really an inflammation of the lens (*phakitis*). When

mechanical injury has produced cataract, or, rather, is producing the disease, we may distinctly note the swelling that characterizes a true inflammatory process. A separation of the tissue of the lens, and entrance into it of the aqueous fluid, is caused by the traumatism. The process is then more active and rapid than that which produces ordinary senile cataract, but it is essentially of the same kind. This view coincides with the most accurate studies we have of its nature, those of Becker (Heidelberg, 1880). This author considers the origin of cataract to be an interruption of the process of sclerosis constantly going on in the lens. This results in a splitting up of the cortical substance. This splitting up is caused by a contraction of the volume of the lens. The spaces left are first filled by normal fluid. The index of refraction of this changes. The divisions then become more distinctly seen by transmitted light. Real opacities now occur, the lens increases in size, and with the microscope molecular opacities and swelling of the fibres are seen. But, as remarked by Hasket Derby,[1] this description of what occurs tells very little of the cause of these opacities. It, however, explains the nature of the process.

The name cataract came from the incorrect idea that the opacity was not in the lens itself, but in front of it. When a French military surgeon, Brisseau, in the year 1705, had found by an examination, on the cadaver, of a cataractous lens, where the opacity really was, he reported his discovery to the French Academy, but he was not believed, and the writings of Galen were adduced as proof that Brisseau was wrong. Three years later, the Academy discovered its mistake, and the true nature of cataract was widely proclaimed and recognized.[2]

Cataract in one of its most common forms is a disease of advancing years. It indicates a loss of general nutrition. Yet it may occur at any age, and it is also, in many instances, a congenital disease. The cataract of middle life is sometimes associated with diabetes, and in a causal way. While we may have other constitutional affections in coincidence with cataract, such as Bright's disease, they seem to be only coincidental, and not, like diabetes, causal. Cataract is sometimes said to be more

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[1] "Ref. Handbook of the Medical Sciences," vol. i., article Cataract, p. 792.
[2] Fuchs, "Lehrbuch," p. 428.

common among the peasantry of France and Germany, than it is with us, the people of these countries, for various reasons, not living as well as the same class in the United States and England, that is, they do not eat as much meat. This view is taken, because cataract appears much more frequently in the foreign clinics than in America. But it is possible that the operation for cataract is more commonly resorted to by the poorer classes of Europe than with us, since there is a capable surgeon in every town of any importance, and an eye clinic, which is very well known, from having been long established. I do not regard it as at all certain that this view is correct. It is not uncommon to find in isolated communities of our country, cataract that has never even been diagnosticated.

DIFFERENT FORMS OF CATARACT.

Cataract may be classified in various ways. For example, we may make a classification of (1) congenital, (2) senile, and (3) traumatic. This is entirely correct as far as it goes. But we need also sub-classification in order that a clear idea may be obtained of the nature of the affection in general. Congenital cataract may be further divided into:

1. Zonular.
2. Punctated.
3. Anterior and posterior polar.
4. Total.

Senile cataract may be classified as incipient, mature, and over-ripe (Morgagnian). An additional classification may be made of capsular cataract. This may include opacities, chiefly in the capsule, which may remain without advancing, through a long life. Some of the so-called capsular cataracts are due to changes in the cortex of the lens, and not to opacities in the capsule itself. There is also an opacity of the lens due to a deposit of lymph on the anterior capsule. This results in some cases of iritis and keratitis. In the latter case, there is a perforation of the cornea, and the opacity from the deposit occurs when this is present, although the cornea may afterward heal, and only the central, chalky-looking opacity of the capsule, remain. This form is also known

as inflammatory cataract. The superficial lens matter just beneath the capsule may become opaque, while the capsule remains transparent. This is called anterior central capsular cataract. If the opacity project beyond the normal plane of the capsule, it is called pyramidal cataract. After these general remarks upon classification and the nature of the various forms of cataract, it will be convenient to study the different varieties under the first heading of congenital and senile, following this by an account of traumatic cataract.

CONGENITAL CATARACT.

Children are sometimes born with an opacity of the lens. As will be seen, it may be circumscribed or diffuse, laminated, capsular, or inflammatory. It may occur as a small deposit upon the capsule or as complete or laminated opacities of the fibres. In the polar cataracts, which do not advance, there is generally nothing to be done but to fit these patients, who are usually astigmatic, highly hypermetropic or myopic, with appropriate glasses, and watch the patient from year to year. If the opacity advances, so that the patient cannot get good vision, an iridectomy should be performed, or if the opacity become general, the lens should be removed. I have observed one case of polar cataract for fourteen years. The patient is now a young farmer of twenty-two. He has a perfectly circular spot on the posterior capsule, which has not changed in appearance since he was eight years of age. After many trials, through various years, he has for the past year worn concave cylindric glasses that give him vision of $\frac{20}{20}$ in each eye.

The opacity of posterior polar cataract, may be due to the abnormally long presence of the obliterated hyaline artery. But it is only the circumscribed, capsular, or cortical opacities, that stand still in this way, and do not seriously impair the vision. Congenital diffuse cataract usually advances quite rapidly. Sometimes at birth the opacity involves all the layers of the lens, and requires early interference. Usually, however, it advances during the early years of life and becomes fit for removal at from four to five to ten years of age. Yet, in many instances, congenital cataracts first come to the surgeon for removal when the patients are in adult life.

At this writing I have under observation a young married woman of about twenty-four years of age, in whom congenital cataracts have very recently become entirely opaque. After three operations on one eye and two on the other, she has vision $\frac{20}{30}$ in the one and $\frac{20}{70}$ in the other. She was treated at the Manhattan Eye and Ear Hospital, one eye being operated upon by my associate, Dr. Frank N. Lewis, and the other by myself.

Among the other consequences of circumscribed opacities of the lens, may be double vision of one eye or even triple or quadruple vision, objects being manifolded according to the number of opacities. I am just now seeing a patient who lost the left eye in youth, who has myopic astigmatism in the right, accompanied by circumscribed opacities apparently in the posterior capsule of the lens and in the vitreous. He is troubled with polyopia in looking at distant objects, such as the moon, stars, and bright point of light, or the light.

Zonular cataract occurring in infancy or before birth is one of the common forms of so-called congenital cataract. A central circular zone or shell of the lens is affected. This zone is surrounded by completely transparent lens substance. With the ophthalmoscopic mirror or by oblique illumination, it may resemble an opaque nucleus of the lens, but close examination will show its nucleus to be transparent. Its diameter varies between five and eight millimetres. This opaque layer may be surrounded by another, equally opaque. Zonular cataract occurs always in both eyes. It is most frequent in rachitic subjects, and in those who have suffered from convulsions in infancy. Sometimes the disease of the lens is less at birth than subsequently. It may exist at birth and be overlooked. The subjects of it shade their eyes to get the advantage of a dilated pupil, go into dark places to thread a needle, and so forth.[1] An iridectomy is a better operation for these zonular cataracts than an operation to promote absorption. The iridectomy gives a good pupil, since the margin of the lens is clear, and we avoid the danger of severe swelling of the lens after a needling operation. It should always be remembered by the operator that a

[1] Derby, *loc. cit.*

very slight interference with the lens may produce a very sudden phakitis, and he who is not prepared for it, may lose the eye before he is ready to remove the lens.

Anterior Polar Cataract.—This is seen as a minute, round white point, of a diameter of from two to two and five-tenths millimetres. A minute corneal opacity sometimes accompanies it. This indicates, as shown by Arlt, an intra-uterine ulcer of the cornea, followed by perforation. The aqueous humor escapes, the lens falls forward, and the corneal exudation adheres to the anterior capsule. On the healing of the ulcer, and the re-establishment of the anterior chamber, the lens goes back to its normal position, but retains the opacity.

Total Congenital Cataract.—This is divided into two forms. In the first, the lens matter is greatly shrivelled, while the capsule is thickened. The more common variety is a general opacity, which is soft. It is soft because it occurs in a lens without a nucleus. The nucleus of the lens is rarely fixed before the thirtieth year. There is a general grayish opacity of the lens, which readily swells, and pushes the iris forward. This form of cataract develops very rapidly. Such a cataract is to be removed by linear extraction or suction. It occurs also in persons of middle life, and then is apt to occur in both eyes, and to be associated with diabetes.

SECONDARY CATARACT.

By this form is understood opacities of the lens occurring after detachment of the retina, in absolute glaucoma, and more rarely in retinitis pigmentosa. In detachment of the retina and in glaucoma, the cataract is usually monocular on its first appearance, simply because double detachments and double absolute glaucoma, of simultaneous origin, are rarely met with. The cataract of retinitis pigmentosa is more likely to be binocular. Total opacity does not occur, but the opacity begins at the posterior pole of the lens and radiates. The opacities occurring after detachment of the retina and absolute glaucoma are usually total at a very early period, but they advance, as a rule, without very marked swelling of the lens.

CAPSULAR CATARACT.

Except as heretofore described in anterior and posterior polar cataract, capsular cataract is a rare affection. In many cases of hypermetropia and hyperopic astigmatism, small black spots are seen on the anterior capsule which remain for years without changing. It is not entirely certain that they may not become detached, especially when they occur on the posterior capsule, and give trouble as a floating body in the vitreous. Capsular opacities also occur in the process of over-ripening of senile cataracts. They seldom occur as independent affections, such as have been already described.

Before the days of the ophthalmoscope, when a thoroughly exact examination was not possible, even with the strongest oblique illumination and magnifying glass, capsular cataract had more importance than it now assumes, when it is found to be generally associated with opacities of the lens structure.

SENILE CATARACT.

This is also denominated hard cataract, but all senile cataracts are hard until they are over-ripe. It is this form that attracts most surgical attention. It is that for which operations are most often performed. Great masses of statistics, from surgeons all over the world, have been published, especially in the last twenty-five years, on senile cataract. Many different operations and modification of operations have been suggested and performed for this condition. From the delicacy and difficulty of the performance of these operations, and from the brilliant and gratifying result of a successful removal of the lens, it being actually a giving of sight to the blind, the subject has assumed almost an exaggerated importance. Some surgeons seem to consider it of more consequence to give a few years more sight to a poor old man or woman, who have never had very important work in life, and from whom little can be expected in any case, than to rescue the eyes of a young man or young woman, who is affected with purulent ophthalmia, and who is in danger of being blind and becoming a tax upon the state during a possibly long life.

The name, black cataract, has been given a sub-variety of senile cataract, when the lens is of a very dark color.

Membranous cataracts are opacities of the capsule, together with neoplastic tissue in the pupil, after the lens has been removed. They are also known as membranes in the pupil.

Diagnosis.—The diagnosis of cataract in any of its varieties, by means of the ophthalmoscope, is not at all a difficult matter. Yet peripheric opacities in old persons with sluggish pupils or punctate opacities in young persons may be overlooked unless a mydriatic (cocaine preferably) is used to secure full dilatation of the pupil. It should be the aim of the surgeon always to make an exact diagnosis of the condition of the lens, especially in persons with asthenopia, or amblyopia, who are in middle or advanced life, but it is not always necessary or proper to give the full diagnosis to the patient, for there are many cases of opacities of the lens which remain isolated, and with little harm to the sharpness of vision, for years. It is interesting to note that opacities of the lens impair the vision very differently in different persons, under, apparently, the same circumstances. For example, one patient, where the opacities seem to be quite extensive, will have a vision of $\frac{20}{50}$, while another under, as far as the ophthalmoscope shows, the same conditions, will only see $\frac{20}{100}$. It is possible in these instances that the varying degree of vision does not depend solely on the opacities of the lens. I know a lady of ninety-four years of age, who has had partial opacity of her lenses for at least fourteen years, and who is still able to read moderately fine type, with ease.

The alarm created in the minds of many persons, by the announcement of the fact that they have cataract, is sometimes excessive, and leads to profound mental depression.

The various forms of lenticular cataract in middle-aged persons or adults present a very different picture in different cases. In some instances there are a few striæ arranged very often in a pyramidal shape at the extreme periphery, and only seen under full dilatation. In others there is a general star-like striation with marked opaque nucleus in the centre. In others again, there are circular spots here and there, looking as if a bit of pigment had adhered to the capsule from the iris. Anterior and posterior polar cataracts, appear as roundish or perfectly

circular films in the centre of the lens. A characteristic appearance of very slowly advancing congenital cataracts, is a central axle-like opacity and spokes radiating as regularly as in a carriage-wheel. In each developed nuclear cataract, there is a general opacity consisting of a yellowish nucleus, surrounded by grayish cortex. This again is modified in some subjects by a general white appearance, with a massing of the cortical material in one or more points. Some old subjects exhibit a general bluish opacity in their lenses, through which the reddish glimmer of the choroidal vessels may be seen with the ophthalmoscope. The observer who has not seen many cases of cataract should be on his guard, lest he pronounce the haziness often seen by ordinary daylight in the pupils of old persons, to be cataract. Such a want of complete transparency is only a senile change, which disappears on observation with artificial light. The most inexperienced observer, however, who has any knowledge of the anatomy of the eye, will have no difficulty in deciding as to the existence of cataract in a pronounced case, when a dense white opacity is seen to fill the entire pupil.

The opacity of the lens that follows chronic glaucoma, has already been described. This is only the last step in the progress to the final condition of hopeless loss of sight, yet such patients have been sent thousands of miles to be operated upon for cataract, because those who sent them did not know how to make an examination that will differentiate curable from incurable opacity of the lens. Even those without special experience need never make this mistake if the following test be applied. It is to be remembered that if cataract be the only disease present in the eye, the perception of light remains good in all parts of the visual field. In any case of complete cataract, the field should be carefully tested with a candle (see page 166). No patient with cataract is fit for operation unless the light is distinctly perceived by him in some part of the visual field. If the perception be sharp, and the field be uninterrupted, the prognosis is good. But if no perception exist, the prognosis is hopelessly bad. It is good in proportion as the field is perfect, as above indicated. There may be conditions, however, such as circumscribed choroiditis, partial detachment of the retina,

when the field is not perfect, and in which an operation is justifiable, and is even to be advised.

Congenital cataract, or cataract that matures in childhood, may cause loss of functional power of the retina, or improper action of the external muscles, nystagmus and strabismus. In adults with senile cataract, after one eye has been successfully operated upon, and the other partially so, but not with a result sufficient for binocular single vision, converging strabismus of the eye not used is sometimes seen. I have been obliged, in some cases of congenital cataract operated upon in young children, to teach them to see. Cheselden's and Ware's [1] observations upon this subject still form interesting reading. The nystagmus of congenital cataract occurs especially in those cases where there is sight enough to enable the patient to grope about alone. It is somewhat relieved immediately after a successful operation, so that fixation becomes more exact. Whether it may become entirely relieved in the lapse of years, I do not know, but I believe it may be. The importance of an early operation is made more marked by the fact of the occurrence of nystagmus as a result of the great impairment of sight. The subjective symptoms of cataract have been necessarily and properly left very much out of consideration, since the diagnosis can be so positively made by the ophthalmoscope. With the older writers, this was not so, as they only had the catoptric test, that is, the appearance of the image of a candle-flame upon the lens, and oblique illumination, to determine the existence of a cataract. To the patient, these symptoms are, in many instances, exceedingly trying, and it is very well if the surgeon is acquainted with them, so that he can dissipate some of the anxieties, and alleviate possibly a little of the distress, which a patient with beginning cataract may experience. When one eye is perfectly sound and the other is completely covered, the patient experiences very little that is unpleasant in his sight, except those difficulties which he soon overcomes, arising from the absence of binocular vision. For example, such a patient cannot estimate distance, does not enjoy a stereoscope, but he soon accustoms himself to this deprivation, and it is not a serious one. I have now under observation an aged jurist, of

[1] Transactions Royal Society of London.

eighty-six, who has had a cataract of one eye for years, and no opacity of the lens of the other eye up to this time, who finds himself perfectly comfortable with his one eye. Some of the unpleasant sensations to which I have alluded, however, are the appearance of floating bodies in the air and atmospheree, the obscuration of sight in a glare, and the disturbance to the sound eye by the one which is very considerably affected.

Patients with cataract not quite enough advanced for an operation, sometimes can have their difficulties alleviated by the use of a mydriatic, so that the pupil may be large enough, even in a very bright place, to admit of tolerably distinct vision. This use of a mydriatic, by preference a weak solution of the sulphate of atropia or of the hydrobromate of scopolamine, is especially valuable where the iris will uncover the least opaque portions of the lens. When this is determined by the ophthalmoscope, the patients may use these drops regularly, even for a number of years, with great benefit to the vision.

As has been intimated, the progress of idiopathic cataract is in most cases very slow. In the average ten to fifteen or more years may elapse before maturity of the opacity occurs. It is from this fact, and also because the growth of cataract is sometimes spontaneously arrested, that the erroneous opinions have arisen that senile cataracts may be removed by the use of the electric current, by trituration, massage, or other methods.

Dr. Richard Kalish, New York,[1] reports success in preventing the maturity of cataract, by daily massage of the lids with a mixture of glycerin and water, equal parts. Although Dr. Kalish's opinions are entitled to respect, from his very considerable experience and position as an expert in ophthalmology, up to this time the profession does not seem to be ready to accept his views. I have, as yet, seen nothing which leads me to believe that the maturity of incipient cataract can be prevented or arrested by any treatment. It is, no doubt, true that straining of the accommodation, in some instances, may hasten the progress of cataract, especially in astigmatic patients. Therefore, a proper precaution, in persons showing slight opacities of the lens, in regard to the manner of occupying themselves, will doubtless be of service in preventing the progress of the disease.

[1] "The Absorption of Immature Cataract by Manipulation Conjoined with Instillation." N. Y. Med. Record, Dec. 20th, 1890.

Many cases of lenticular opacities cease to advance without any treatment whatever. The only effect I have seen from the method of trituration is a hastening of the ripening of the cataract. There is, as yet, no means known for the removal of a cataract except through operation, and yet absorption may spontaneously occur, at least in part, or the process of ripening be arrested in a small proportion of cases. It is probably true that many persons live and die with a fair degree of sight, being able to read small type, and so forth, who have opacities of the lenses that never come under the observation of an ophthalmic surgeon. I am led to this belief from the number of cases I have watched for years, without observing any notable advance. These are generally, if not always, cases of lamellated cataract.

If cataract be left to become over-ripe, the cortical material slowly dissolves and leaves a small nucleus behind, which together with the opaque and dried capsule forms quite as much an impairment of vision as the fully matured general opacity of the lens. In such cases, other changes occur in the eye, the iris atrophies and loses its color, becomes tremulous from want of support, and the globe itself may become soft. The prognosis is then bad. Too much time has been lost. The cataract should have been removed when ripe. This stage is reached when the patient can no longer discover objects, but has quantitative perception, that is to say, ability to distinguish light from darkness, and light of varied intensity, but not, for example, to count fingers, or discern other objects as such. Objectively a cataract is ripe when it covers the whole area of the pupil, and no shadow is cast by the iris, even on full dilatation.

In the classification of cataract much was formerly said of the Morgagnian cataract. This is really but an over-ripe senile cataract. The cortical matter in these cases has become fluid and left the nucleus bathed in it. Such a condition is fully comprehended under the retrogressive changes of nuclear cataract, and only requires an incidental mention.

GLAUCOMA FROM SWELLING OF THE LENS.

Traumatic cataracts become dangerous from their disposition to swell rapidly, and thus to increase the tension of the eyeball (artificial glaucoma) and finally destroy it. It is always nec-

essary to interfere promptly, and to remove the swelling lens matter, in whole or in part, when this occurs.

The following is an illustrative case:

Wound of Cornea, Iris, and Lens.—Traumatic Cataract.—July 10, 1883. Mrs. E. L. W., age 35, yesterday forenoon was taking out tacks with dinner-knife, when a tack (?) sprung up and struck her in the eye. Sight lost. Cornea of left eye perforated half-way between pupil and corneal junction. Iris behind it perforated and cataract resulted. Right eye has been watering since last night, light hurts it, is slightly red. Patient is so nervous that it is hard to tell anything about her sight. R. E. $=\frac{20}{30}$. Not improved with glasses. L. E. = perception of light. Lens opacity. Synechia posterior outer half. Atropine was applied.

July 17th.—Has had very little pain in her left eye. Sees as well now with her right eye as she did before; never did see very well. R. V. $=\frac{20}{50}$; 2 J. at 8 inches (sideways). Left pupil irregularly dilated, lens swollen, and protrudes into anterior chamber. Continue atropia and shade.

July 23d.—Condition same as last visit.

August 25th.—Redness entirely gone, pupil partly dilated, lens matter in anterior chamber. R. V. $=\frac{20}{50}$. Has had some atropia in right eye. Left eye, V = moving objects. Continue atropia.

November 3d.—R. V. $=\frac{20}{50}$, L. V. $=\frac{20}{40}$; W $+\frac{1}{2}$ $\frac{1}{2}$, the lens matter having been nearly entirely absorbed. Pupil of left eye nearly round. Small amount of capsule remaining in the lower part. Advise $+\frac{1}{2}$. Reads 1 J. at 10 inches.

Remarks.—In this case there never was any artificial glaucoma. Although the patient was thirty-five, the absorption went on safely, without any interference. This, however, would not be generally the case.

THE RIPENING OF CATARACT.

In some cases of slowly advancing senile or even congenital cataract, it may be proper to hasten the process of ripening, since if this be not done, it goes on so slowly as to deprive the patient of nearly all useful vision for years, during which, after a successful operation, it might be enjoyed. For ripening cataracts, I prefer the method of Foerster (Breslau, 1870), which consists in the performance of an iridectomy in conjunction with massage of the cornea for a very few minutes, say two or three,

with a spatula or strabismus hook. While serious and rapid phakitis may result from this operation, it is very unusual, and the surgeon may confidently undertake Foerster's method for ripening cataract in appropriate cases. Such cases must be kept under careful observation from the time of the operation, for, while the ripening may go on gradually and simply and give the surgeon ample time, on the other hand it may go on so rapidly as to require the removal of the lens in four or five days after the iridectomy has been performed. I am inclined to believe that the iridectomy is the chief factor in the production of maturity of the cataract, and that the trituration or massage of the cornea has very little to do with it. In even very carefully performed iridectomies for glaucoma, we not unfrequently see opacities of the lens result, which I believe is not necessarily due to the contact of the point of the knife with the capsule, but to the concussion of the lenticular constituents. Dr. Pooley, New York, modified Foerster's operation by performing a delicate paracentesis of the capsule. This is, in its nature, a more dangerous operation, that is to say, more likely to be followed by rapid swelling of the lens, than a simple iridectomy.

TRAUMATIC CATARACT.

Traumatic cataracts form one important class by themselves, and require especial consideration. Nowhere in ophthalmic surgery will better judgment be required than in the management of traumatic opacities of the lens. They occur in all ages, and under the most different circumstances. The cataract occurring in glaucoma after the operation of iridectomy may properly be classed under the head of a traumatic form. But this is not the variety usually in mind when speaking of traumatic cataract. Traumatic cataract may be merely one of the many results of a serious injury of the eye involving all of its tissues, in which the opacity of the lens, immediate or subsequent, is a mere incident. But there is a large class of cases in which the eye, except the cornea and lens, has received no injury, and where we may expect a considerable restoration of vision, and a useful eye, if we can remove the lens.

The following table of the last cases of traumatic cataract, treated in the wards of the Manhattan Eye and Ear Hospital,

gives an idea of the various sources of injury. These are cases in which, beyond the damage to the lens, the eyeball is not supposed to be seriously injured. Cases of wound in the ciliary region or detachments of the retina, or destructive inflammations of the whole eyeball from injury, even if cataract have also resulted, are carefully excluded from this table. They are cases in which treatment for the removal of the cataract affords a good prospect of success.

Table Showing the Ordinary Causes of Traumatic Cataract.

Struck in eye with a stone	7
" by nail flying from a hammer	2
" " missile from torpedo explosion	2
" " tack, while shaking a rug	2
" " piece of coal	1
" " chip of steel from chisel or hammer	7
" " piece of wood	1
Ran against a fork held by a child	1
Struck by a piece of glass	1
" " whip-lash	2
Falling down and striking face	2
Struck in eye by a thorn	2
" " " hair-brush	1
Cutting wire, a piece hits the eye	3
The end of a file enters the eye	1
Gunpowder explosion (firecracker)	3
Struck with a horseshoe	1
" " piece of tin from cutting with scissors	1
" " scissors (child four years old)	1
" by piece of mortar and sand thrown at patient	1
" " baseball	1
Capsule accidentally ruptured by keratome in performing an iridectomy	1
Cork from soda-water bottle	1
Blow in the eye with a fist	2
	47

Table Compiled from Private Practice.

Eye injured by blow from the fist	5
Struck with piece of wood	2
" by piece of nail	4
Struck by wooden plug shot from pistol	1

Stuck penknife in eye	1
Thrown from load of hay, striking on vertex	1
Stick run through upper lid of left eye	1
Hit by piece of chisel	1
Wounded by buckshot from air-gun	1
Explosion of gunpowder	1
Struck by hair-pin	1
" by arrow	1
Hit by ball	1
Blow from stick	1
Injured by fork-prong	1
Struck by awl	1
Cut by scissors	1
Injured by falling downstairs	1
Hit by piece of coal	2
Hit by stone	3
Injured by tack	1
Hit by needle	1
Hit by piece of iron	1
	34

I have recently treated a case of traumatic cataract in a young girl of eleven years of age, which occurred in rather a remarkable way. She was standing in front of her dressing-table, and took up a handkerchief and shook it playfully at a little friend sitting near. A needle was in the handkerchief, which fell out and hit the cornea, passed through, and entered the lens. The sight of the eye was at once very much impaired. The cataract that followed was removed by a linear section some weeks after, and a good recovery resulted, although a severe iritis followed the extraction. This case is remarkable for the fact, that during the operation, the iris lost its normal color under our eyes, and while there were objective evidences of very severe iritis in this discoloration and in the swelling, and subjectively, in the loss of sight, the patient scarcely suffered.

If the instrument or missile or foreign body, enter directly through the cornea, and do not pass into any part of the ciliary region or sclera, the chances of saving the eye by removing the lens are very good, and I have sometimes succeeded in so doing, but in the following case, the operation failed to achieve this result, and I think because the patient was not operated upon at an early enough date, and also perhaps because he was a debilitated subject.

REMOVAL OF LENS CONTAINING A FOREIGN BODY.

Foreign Body in Lens.—Traumatic Cataract.—April 15th, 1892. Mr. G. F., age 66. Ten days ago was struck in the left eye with a piece of iron. The sight was impaired at once, slightly; an hour after the injury began to have pain. Saw a surgeon who gave him some drops. For a week had no trouble except the blurring. Two days ago began having pain, which has continued. Was turning off a nut with a chisel when the accident occurred. R. E. $= \frac{20}{40}$. L. E. $= \frac{8}{100}$; opacity of cornea very minute to outer side of the lenticular opacity. Just behind the corneal opacity, is a white spot on the anterior surface of the lens, with an opaque line extending to a dark object in the posterior part of the lens. Periphery of lens is opaque.

Adv. and Treatment.—Atropia. Attempt to remove the lens.

Extraction of Traumatic Cataract, April 16th.—The lens was removed by corneal section under ether. A foreign body was found imbedded in the nucleus of the lens. The bandage was changed the same evening. Corneal flap was slightly hazy at edge.

Although the lens was extracted with the foreign body, without particular damage, the flap did not heal, circumscribed suppuration followed, and the patient, who was rather a feeble man for his years, only recovered with the eyeball intact, or with no vision.

Where the ciliary region or even only the sclera, is wounded, the case falls under those likely to produce sympathetic ophthalmia, and out of the category of those we are now discussing. Powder burns, from explosions near the eye, form another frequent source of traumatic cataract. Grains of powder entering the eye are comparatively innocuous, perhaps because of the aseptic quality of gun-powder, but this contact with the lens will produce phakitis and traumatic cataract.

Any kind of a foreign body entering the lens, will produce cataract. Very rarely, if ever, does a foreign body in the lens remain isolated or become encapsulated, but in a brief period general opacity occurs; sometimes only a few hours from its entrance proliferation of the lenticular tissue and opacity result. A blow upon the eye, generally produces more serious injury than cataract, such as dislocation of the lens, detachment of the retina, rupture of the choroid, or wound of the globe, or the like, but such a blow may do none of these things, and produce only an opacity of the lens. Penetrating wounds of the cornea, are

almost invariably attended by injuries of the lens, and then almost always result in cataract. If the wound be large, the aqueous humor will immediately escape into it, and it will very soon lose its transparency, in a few hours; but if the wound of the capsule be small the formation of the cataract will be much slower. In rare cases, a small wound of the capsule produces a small circumscribed opacity, which remains stationary. As Lawson[1] says, such a happy incident more frequently occurs in the old than the young subject, simply because the young person has a softer lens than the middle-aged or old person. In traumatic cataract, the less the iris is involved the better the chances of success. If it be prolapsed, it should be cut off.

In examining some cases of cataract that appear in the clinics, where there is no trace of an injury of the cornea, but a positive history of a blow upon the front of the eye some time before, we can assume that the cataract was caused by concussion, and this agrees with our knowledge of the disease from other sources, especially in cataract occurring after the operation of iridectomy.

CATARACT FOLLOWING A STROKE OF LIGHTNING.

It has been observed that changes in the lenses occur after hanging, and also, in rare instances, as the result of being struck by lightning. The following case well illustrates these changes produced by a stroke of lightning. Its fortunate termination is exceedingly instructive.

The subject was a patient, a young woman of twenty-eight years, who, while picnicking in the fields of Colorado, was overtaken by a severe storm from which she took shelter under a tree, where the accident happened. She discovered the impairment of vision after she recovered from the general shock. Examination a few weeks afterward showed that there were opacities of each lens. When I saw her, there were not only diffuse opacities composed of irregular wave-like lines, but also radiate opacities, especially in the eye with the least vision. Her vision was in the right eye $\frac{20}{100}$, but she could only read No. 11 Jaeger. In the other eye the vision was $\frac{20}{70}$, and she could read No. 4 Jaeger. Two months after, her vision

[1] "Injuries of the Eye," London, 1867, p. 126.

was the same. The opacities seemed to remain stationary, and she was advised to await the ripening process, unless it went on very slowly.

I have never seen this young lady since, but I was so much interested in her case that I wrote to her, and received the following replies from herself and her physician, which show that the ripening of the cataract has been arrested, and she has been able to do without an operation:

"In order to give you a satisfactory statement of the present condition of my eyes, I went to Dr. Rivers of this city, who examined them, and kindly said he would write you himself, and send the pictures which he made of the cataracts. There is therefore nothing left for me to do but to give an account of the change which took place in my sight between the time when I saw you in March, 1889, and the present. I noticed no difference in the sight of either eye for about a year; they seemed to grow neither worse nor better, but the 'fire-balls' which I saw so often gradually appeared less and less, and at length only troubled me after loss of sleep, a long time in the bright sunlight, or anything else which made my eyes tired. For several weeks in the spring of 1890 I was conscious of an improvement taking place in my sight, and when my friends also noticed that I appeared to be able to see better, and questioned me about it, I acknowledged the fact which I had not cared to speak of before, fearing the improvement less than I imagined, or that I was only growing more accustomed to my condition. So you can see how very slowly the change took place. By the middle of the summer, however, I could read ordinary print very well, and so the improvement went on very slowly for a year or two. But the change was only in the right eye, I found; the left remained unchanged for some time, so far as I could judge. For the past year, however, its sight has been growing slightly more dimmed, until it is in the condition which Dr. Rivers will describe to you. About three months after I saw you, I was visiting friends in Montreal, and being advised to consult Dr. Buller, I did so. He was of the opinion then that the cataracts were not maturing as rapidly as they had been, and a second examination three months later on showed that they had not changed, and the doctor expressed the opinion, that they would remain as they were for a great many years, perhaps for the remainder of my life. Since my second visit to Dr. Buller, I have not had my eyes examined, until I went to Dr. Rivers the other day with your letter. My health has been pretty good most of the time, though I was not quite so well as usual last year."

DENVER, COL., March 12, 1894.

"Miss L——, a nurse in our hospital, requested me to examine her eyes, and report to you their condition.

"You will remember several years ago she was struck by lightning, and several months afterward you found immature cataracts. Dr. Buller, of Montreal, also examined her, and gave her practically the same prognosis, that she would have to be operated on in a few months.

"My examination shows:

"*O. D. Vision*$=\frac{20}{30}+$, not improved by lenses; reads Jaeger No. 1 at 15 cm. out to 29 cm. from eye, with ease.

"*O. S. Vision*$=\frac{20}{70}$; no improvement with lenses; reads No. 2 Jaeger, with great difficulty.

"Pupils dilated with homatropine for ophthalmoscopic examination, shows pupils dilated *ad maximum*, perfectly round. Lens partially opaque in posterior portion, more especially at posterior pole as shown in drawings.

"Fundus normal in each eye. Disc and vessels in right eye can be seen through the lens in its whole area, including centre, but the light streaks cannot be seen. In the left eye, besides the posterior opacity, a few streaks (of opacity) are in anterior surface of lens. Disc very indistinctly seen through any portion of lens, and not at all through the centre.

"She says that when you examined her, her left eye was the better of the two, and since then she thinks the left eye has remained nearly in the same condition, but the right one has so improved that it is now—as above shown—very much the better.

"Yours very truly,

"E. C. RIVERS."

It will be seen from the account of the above interesting case, that the lenses are not undergoing absorption, but that the opacities have actually diminished, and the volume of the lens remains unchanged. The positive evidence of the influence of electricity upon the lens, is here complete, because the young woman, who was an educated and intelligent person, knew that her sight was excellent until this accident occurred.

TREATMENT OF CATARACT.

In spite of all that has been written, there are no constitutional or local means of treatment, by which opacities of the lens

can be removed without a cutting operation. Their absorption cannot be hastened by the application of agents to the eye, or the administration of medicines. Beyond the unaided processes of nature, a surgical operation, and that alone, will be of avail. It is not to be denied, however, that if cataracts be discovered early, and the nutrition be very carefully observed, and all straining of the eyes under unfavorable conditions be avoided, the advance of the opacity may be delayed, perhaps arrested. The proper treatment for senile cataract will be first discussed.

The operations now performed are those of simple extraction or modified simple extraction, that is to say, a flap operation with a narrow Graefe knife, without an iridectomy, or the same operation in conjunction with an iridectomy. Luxation of the lens by a needle, an operation performed until the nineteenth century by travelling oculists, who went from market-town to market-town in the continent of Europe, and by reputable surgeons in England and this country until 1840, is now everywhere in civilized countries abandoned. The knife of Beer, of triangular shape, very difficult to use successfully, has been given up since Graefe proposed the modified linear operation. But the knife alone remains of Graefe's operation, except when iridectomy is performed. We have come around the circle, to the simple extraction of Daviel and Beer and Ware,[1] with also a survival, in slowly ripening cases, of Foerster's preliminary iridectomy, and an occasional extraction of the lens in its capsule. This latter procedure may always be recommended in those cases where, after the section is made, the lens is seen readily to escape without the necessity of entering the eye with a capsulotome. The results of the operation, as now performed, are pre-eminently successful. A very small percentage, not more than five to seven, is lost in the hands of experienced operators. After the peripheric linear operation was generally adopted, Horner placed the losses at 2.67 per cent. This is too low for ordinary unselected statistics. It has been remarked that there is nothing so misleading as statistics. While this may not be literally true, it is true that statistical tables of the results of operations sometimes have a subjective coloring, which requires that they must be carefully considered in all their bearings be-

[1] Transactions Royal Society of London, 1801.

fore their summing up is accepted. There are some newspapers whose headlines do not correctly represent the actual news detailed below. There are also some percentages of cases in operations for cataract not justified by a careful reading of the reports of the cases themselves.

The method of performing the various operations for cataract has already been described in Chapter X., but there remains much to be said on the general causes of success or failure, with an account of the proper after-treatment. The constitutional condition and temperament of the patient have something to do with the success of an operation. Fortunately, the progress of time blunts the sensibilities, and restrains the emotions of many subjects of senile cataract. They have weathered so many storms in their long lives, that one more does not surprise them. Besides, they come gradually to their loss of sight, and they are not shocked or unnerved by it, but this is not always the case.—Valuable as is cocaine in cataract operations, general anæsthesia has an advantage of its own.

Nervous and excitable patients are so occupied with the unpleasant consequences of their etherization, that they have no thought for their eyes, and, as soon as the nausea is recovered from, are apt to fall into sleep. To secure a good night's rest is one of the most important duties to be accomplished for a patient after an operation for cataract. It promotes healing of the wounds in the first twenty-four hours. That once achieved, the greatest danger of suppuration is over. Very severe iritis may occur and last for days and yet the patient recover good sight, but if a suppurative process in the cornea or iris once occurs, the chances of saving the eye, even if all the known things be done, are nearly nil. Cauterization of the lips of the wound with the actual cautery or carbolic acid, may be tried. Some success has been recorded from this procedure. The only eyes that I have succeeded in saving, when corneal suppuration has once set in, have been those in which hot fomentations or iced cloths were used, and the suppurative process has become circumscribed, but whether from the applications or not, I cannot say.

The dangers occurring during the operation itself have been fully detailed in the chapter in which the operation and its accidents have been described.

After-Treatment.—The after-treatment of a case of extraction is very simple. While I would not go to the lengths that are advised by some operators, much larger liberty is to be allowed the patient than was formerly thought proper. Arlt sometimes detailed an assistant to hold a patient's head, for some hours after an extraction of cataract, and in Graefe's clinic during my pupilage there, the hands were always fastened so that they could not reach the eyes, by linen or cotton bands, and among all operators, up to a few years ago, it was advised that the patient be kept in a very dark room, absolutely on the back without stirring, for from twenty-four to thirty-six hours. A patient may be operated upon on a table and removed to the bed, without danger. He may sleep in a semi-lighted room, a room light enough for the patient's attendant to read. His position may be changed in bed, if carefully done, but it is better, when senile delirium, not uncommon after an operation for cataract, or great restlessness occurs, to let the patient get about in the room, than to attempt to confine him, or even to leave the eyes bandaged if the patient incline very much to tear the bandages off. In a few such instances, in my practice, the most violent actions, uncontrollable movements so that all bandaging was given up, the patients recovered excellent vision. One was that of a lady of ninety-two years of age, who lived some two years and a half to enjoy her eyesight. But, on the other hand, the loss of eyes may be directly traced to the patient's own carelessness and rough handling of the bandage.

As has been intimated, some authors grant great liberties to all patients. Knapp has lately advised, that the patient undress after instead of before the operation, and that the eye be left unbandaged for an hour or two. Another authority, Cheatham, of Louisville, Ky., allows a patient to ride home some miles in a wagon over a country road, immediately after an operation. A surgeon resident in Mexico, who goes about the various cities of that country to operate for cataract, informs me that he simply bandages the eyes very carefully, and permits the patient to go home and return, as if the case were that of an ordinary out-patient.

Twenty years ago, I tried faithfully the after-treatment by closing the eye with strips of isinglass plaster, but I soon re-

turned to the flannel bandage as suggested by Graefe, and which I learned to use in his clinic. I believe patients usually find this a comfortable dressing, and that it gives a sense of safety to the eye, which most thoughtful patients require. But I advise that the hands be restrained by a bandage, so that in sleep they may not be lifted up to the forehead.

I am not in favor of opening an eye that has been operated upon for cataract, sooner than four or five or even six days after the operation, unless signs of inflammation are marked. The bandage may, however, be removed every twenty-four hours, and the face bathed if it will contribute to the comfort of a patient, while the eye is not opened. I share the horror, long ago expressed by the late Dr. Cornelius Agnew, of a "peeping pathologist," who persists in seeing an eye that is apparently doing well, before the wound can have at all firmly closed. This is pulling up potatoes to see if they grow. Even when four days have elapsed, and the eye is opened and the pupil and wound be examined, this must be done with the greatest care, or the wound may be reopened and prolapse of the iris, or even of the iris and vitreous may occur. Patients snap the eyes together even under the most careful management in some cases, and thus cause irreparable accidents.

The argument for not opening eyes that have been operated upon for senile cataract until some days after, it seems to me, is nowhere better put than by Dr. Hasket Derby.[1] Since it represents very well my own opinions, I reproduce it here. Dr. Derby states that there is a great difference of opinion as to when the lids should be first separated and the eye examined. One of the greatest of authorities, the late Professor Arlt, suggested that the lids may be separated twenty-four hours after the operation, and sooner, if necessary. Dr. Derby came to the conclusion that the eye did quite as well if the lids were allowed to remain closed two, or even three, days, and as his experience increased, he says that a new fact forces itself repeatedly to his notice: That in certain cases, in which the healing process was interrupted by inflammation, the first pain, lachrymation, or discharge followed accurately on the first separation of the lids.

[1] "Reference Hand-Book of the Medical Sciences," Wm. Wood & Co., vol. i., p. 803.

however carefully it was done, and however short a time was consumed in the examination. He found that when the case had been doing perfectly well for three or four days, and not the slightest pain experienced, and the eye opened and looked at very quickly with a weak light, no lens used, and no trial of vision made, yet within a few hours pain would occur, and decided symptoms of inflammation appear. This happened, as Dr. Derby continues, so frequently, that it became impossible for him not to connect the examination and the inflammation, as to cause and effect. Acting on this belief, he continued to prolong the time that he allowed the eye to remain unopened. Dr. Derby first announced these views in 1881.[1] At the present writing he continues to adhere to them, he says that he rarely makes the first examination before the morning of the eighth day.

Dr. Derby's experience so exactly tallies with mine in this matter of associating early opening of the eye with the causation of inflammation, that I am very glad to quote somewhat in detail what he has said, to express my own views. While I may change the bandage every twenty-four or every forty-eight hours, if the patient be uncomfortable, I do not open the eye until the fifth or sixth day, unless evidence in the red lid, the great pain, or the swelling forces me to conclude that an active inflammatory process is going on. If that is present, of course the eye must be opened, and the origin of the inflammation and its character traced out. In this connection, it is well to state, that I have found the solutions of atropia in castor oil, very beneficial in their influence upon eyes very much inflamed after cataract operation. The reaction to oily solution is much less than that from watery ones. I now invariably use them in such cases. The patients seldom know that a drop has been applied, and do not snap their lids together when the oil is used.

The young operator should be on his guard against putting his hands even on the edge of the upper lid, or on the eyebrows while causing the patient to look down, in the first few days, after extraction of the cataract. The edge of the wound is sometimes so rough, as to cause great pain when the eye is moved downward. Besides the pressure of the surgeon's finger

[1] American Ophthalmological Society.

may compel nervous persons to jerk the eye away from his hands. I have had the misfortune to see the wound of the cornea reopened, by the snapping together of the eyelids in several cases, and in a few, the eye was lost from prolapse of the iris and the vitreous. The operated eye will tolerate even a light blow upon the bandage, better than such a snapping together of the lids. The various eye-protectors that have been invented, two of which are here described, often serve an excellent purpose, but chiefly with intelligent and careful patients. Stupid and careless patients will deliberately do harm to their eyes. There is absolutely nothing that will guard eyes from mischievous handling on the part of such patients, except possibly tying the hands to the side of the bed, so that they cannot raise them high enough to reach the bandage. This sometimes is inefficacious, because they loosen their hands from the restraint.

Fig. 157. McCoy's Protector.

After the cornea has thoroughly healed, a simple pledget of cotton, with a protective black patch, as shown in the cut on page 189, chapter IX., may be worn. This in a few days is to be in turn replaced by a simple shade or a pair of colored glasses, and the patient allowed to go out-of-doors.

PROTECTIVE BANDAGES.

Fig. 157 illustrates the protective apparatus invented by Dr. T. J. McCoy, formerly house surgeon in the Manhattan Eye and Ear Hospital. It consists essentially of two wire protectors, shaped like a very large watch-crystal, fastened to the eye with tapes.

The ocular mask, designed by Dr. Frank W. Ring, is used as a protection for the eye after operation. It is made of *papier mâché*, covered with black silk and lined with white linen. It is moulded to fit the parts about the eyes and rounded out, so that the eye is protected. Tapes are used to hold it in place, and it may be used over a bandage, or simply with cotton over the eye. A hole is easily cut over one eye if desired.

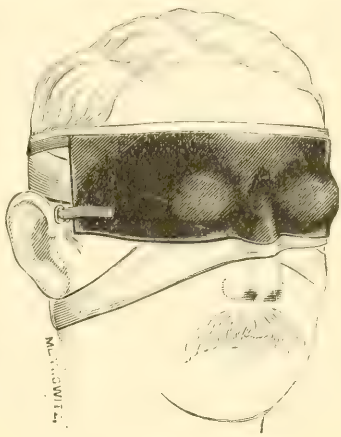

FIG. 158.—RING'S PROTECTOR.

ORDERING GLASSES AFTER AN OPERATION.

It is not well to order glasses until some four to six weeks after a successful operation, for several reasons, among which are:

1. The fact that the corneal astigmatism caused by the section, will diminish very much in a few weeks. It may be eight to ten diopters immediately after the operation, and become as little as two. It is very important in many cases to prescribe cylindric glasses, since they will often make a vast difference in the capacity to see, specially at a distance.

2. Patients may strain their eyes by over-use, if allowed glasses at too early a period. I have known serious iritis occurring some weeks after an operation, to be directly traced to over-use of the eyes.

WHEN SHALL OPERATIONS BE PERFORMED?

Among the many questions properly to be considered in discussing the expediency of an operation for cataract, is, Shall we advise an operation on one eye, where the other is sound, or nearly so? A direct answer that will include all the conditions cannot be given to this question. If a patient be very old and feeble, and have one eye with which he is able to read, or even only to get about with assistance, without being able to be employed on fine occupations, and if his general health does not admit of manual labor, there will manifestly be no advantage

in operating upon the cataractous eye, even if the cataract be fully ripe and the local conditions are favorable to a successful operation.

Again, if the fellow-eye, as I have seen it in several notable cases, be entirely free from opacity of the lens, while the cataractous eye is ready for an operation, I think the matter, if the patient be intelligent, may be left entirely to his or her judgment, as to whether the slight risk of an operation should be undertaken, in order that there may be an eye in reserve in case opacity of the fellow begins as it is likely to. Yet I have observed two cases for more than fifteen years, in which fully mature senile cataract of one eye, has not been followed by any opacity whatever of the fellow-eye. In young persons with cataract this is not uncommon. Where, however, one eye is ready for extraction, and the other has begun to be impaired, so that occupations on small objects are not easily undertaken, I should urge operation on the mature cataract, if the patient were one in a position in life requiring the use of his eyes in reading and so forth, and if he or she be in fairly good health, not too old, say from fifty-five to seventy years of age. But even persons in very advanced years should not be denied an operation on that ground alone.

It should be remembered as a fact leaning toward an operation in such cases, that over-ripe cataracts undergo degeneration and absorption, as a natural consecutive pathological process. When maturity of a cataract occurs, the law of nature goes on to fulfilment, and dissolution follows; the so-called *Morgagnian* cataract results. Were the absorption of the lens always complete, were none of the lens or capsule left behind or not enough to prevent good vision, did the eye not become irritable, as a result of the slowly deliquescing process, we might in such cases leave the eye to its inevitable clearing up of the lens, the other being sound; but the process being often accompanied by choroiditis, which may impair the vision and soften the globe while the lens is dissolving, we cannot safely leave an over-ripe cataract. Indeed, it is harder to remove the whole of an over-ripe lens in an extraction, than one that is just mature. It is certainly better not to await this condition, but if a cataract is to be removed, to do so when it is just ripe. Of

hastening the maturity of slowly advancing cataracts, full notice has already been taken.

Another question is, In two ripe cataracts, shall both be removed at the same time? To this I unhesitatingly give a negative answer. I am aware that many successful operations of this kind have been performed, but it is taking a risk to perform them—a risk of total loss of both eyes, that I think no surgeon is justified in assuming. If an unsuccessful operation be performed on one eye, and the surgeon has still the confidence of the patient, he has learned much that will be of the greatest service in avoiding a subsequent failure. If a bad process set in in one eye, it is very apt to occur in the other at the same time, and the chances really are greater of losing both eyes than if one is operated upon at a time. One eye is sufficient for the purposes of even an exacting life, as there are many eminent examples among statesmen and writers, who have achieved all their success with vision on but one side, although there are not wanting a few examples of great success with nearly complete blindness of both eyes, notably in this country the historian Prescott, and in England Mr. Fawcett, the statesman, a member of Mr. Gladstone's cabinet as postmaster-general. These cases are entirely exceptional, and only emphasize the serious handicapping produced by blindness, while with one good eye, no man or woman need necessarily shrink from undertaking any duty, or consider the loss a positive bar to success.

All this has an important bearing on the question, one eye having undergone a successful operation, shall the lens, where ripe, be extracted from the other also? If the one eye from which the lens has been removed is in any way deficient, and cannot be said to have furnished even approximately a good result—if, for example, capsule remains in it, or there is an incarcerated iris, or a poor pupil, and reading and writing are only undertaken with difficulty, if at all—I would advise that the second eye be operated upon with the hope of giving a more useful eye. But if the eye upon which an operation has been performed, has good vision, say $\frac{20}{30}$ or even $\frac{20}{40}$ or $\frac{20}{50}$, and No. 1 Jaeger can be read, I should hesitate very much about operating upon the second eye. Yet I have always done so, where the patient, knowing the slight risks, wished to take them. It

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is an operation that may be properly performed, but not urged upon a patient or his friends. In all this, I am speaking of the cataract of age, and not that of youth, nor of traumatic cataract.

Operations for cataract, may properly be performed upon diabetic patients, those suffering from chronic Bright's disease, and upon very old and feeble people. Cataract is a disease of old age, of prematurely old people, and of those who are from one cause or another somewhat enfeebled. We cannot always expect to find vigorous men and women suffering from senile cataract, and we should take our chances with them, if the local conditions warrant an operation. I do not wish to be understood by this as saying that persons with average physique do not have senile cataract. This is notably so, especially in those with astigmatism or myopia, through which there has been considerable accommodative strain. It is no doubt true that local as well as constitutional conditions play a large part in the formation of opacities of the lens.

Cataract may be operated upon at any time of the year, but it is better to avoid the very hot months for operations in cities. A hospital, public or private, is the most suitable place for such an operation, provided the hospital be a quiet one, with ophthalmic wards. Better opportunities for recovery can be given under such circumstances, than in the best of homes. Yet I have operated successfully in tenement-houses, and I cannot say that I ever saw an eye lost, from the character of the building in which the operation for cataract was performed. With a little care, the essentials for success can be provided for in very plain apartments. Good air has very much to do with success in treatment. Cases will recover sight in country air, that would not do so in the atmosphere of a hospital in the city. But the average cases, with good performance of the operation, will do well under almost any fairly good conditions.

THE RESULT OF AN OPERATION FOR SENILE CATARACT.

In some and happily a large percentage of cases, in simple extraction, or simple extraction with iridectomy, the cornea heals promptly. There is no incarceration of iris in the former class, no serious iritis in either, and in three weeks the patient

is going about out-of-doors, with blue glasses, and with very fair vision. Beyond a little uneasiness a few hours after the operation, from an accumulation of mucus and tears in the conjunctival sac, and a little tenderness of the globe, and photophobia, such patients have suffered very little inconvenience, much less pain. Glasses are fitted to the eye, and they finish their days with excellent vision. But although these cases constantly occur, they are ideal in their course and progress.[1] Many others suffer much more, and yet have finally very useful eyes, which also last to the end of a long lifetime. In these cases severe iritis may set in from the fourth even to the twelfth day, although the latter limit is rather long, and the former rather short. In such eyes the lachrymation, the pain, and the excessive photophobia, with the congestion, soon call attention to the case. If the corneal wound be closed, the case is simply one of iritis, which is to be vigorously combated, according to its severity, with frequent instillations of a two or four grain solution of sulphate of atropia, or a one-grain solution of scopolamine, with leeches, with cold or hot applications, and perhaps with hypodermic injections of pilocarpine. If the inflammation lead, as it may, to closure of the pupil by a membrane, this should be divided, but not until all the other inflammation has subsided, and the eye has been quiet for several weeks. Incarcerated iris it is better to leave to shrink away, unless it be cut off in the very first hours of its occurrence.

In other cases, the iritis becomes so violent, and draws with it the choroid, the vitreous humor, and the capsule so actively into the process that the eye is finally lost, atrophy ensues, and it may become a source of irritation to be removed. This latter effect is much more apt to happen if the incision be made, as Graefe first advised in his operation, too far from the *limbus corneæ*, in fact in the ciliary region. Such an incision should never be wittingly made, but it must always be in the clear corneal tissue. It is remarkable that so great a surgeon as Graefe, could have advised an operation with an incision in the scleral region, and that he had any followers in its performance.

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[1] I saw one ideal case in the practice of Dr. W. Oliver Moore, when in three days, perfect union of the wound had occurred.

Incarcerated iris may also cause an irritable and painful eyeball. If suppuration of the cornea or of the iris itself occur, it will make itself known in not less than fifty-six hours. Years after a successful operation, membranes may form in the pupil, and in rare instances detachment of the retina may occur. For the former correction, a division of the membrane will generally give as good a result, as an operation for a membrane that has formed a few weeks after the operation. The latter condition is hopeless.

If the eyeball undergoes atrophy, it is safer to remove it before operating upon the second eye. Left behind, it may be a source of irritation. If tender or painful, there is no option, it should be removed.

Some writers have laid very much stress on the recent advances in local cleanliness and antiseptic treatment which have been made since the investigations of Lister, as having greatly improved the chances of a succcessful operation for extraction of cataract. This is, indeed, true, not because, in my opinion, any particular applications of bichloride or carbolic acid solutions have been made to the eye, nor because the anterior chamber has been sterilized, as it was for a long time by some operators, led by Panas, of Paris, with the injection of a solution of biniodide of mercury, but because every surgeon has learned the necessity for absolute cleanliness of his instruments, of the seat of operation, and of the clothing of the operator and the assistants. It is remarkable, however, that some operators, who lay great stress upon antiseptics, will operate upon the eye in aprons and gowns, which they have worn while treating contagious cases. The operator for cataract, should protect his person with clean linen, wash his hands and wrists, and look after his finger-nails as thoroughly as a general surgeon, but after all has been done, and a mechanically perfect operation has been performed, with aseptic instruments and aseptic hands, suppuration of the cornea or iris may occur. One of the most important factors in producing suppuration of the cornea or of the iris, after a cataract operation, in my opinion, is what is known as "a nervous constitution" of the patient. By this I mean a fretful, irritable patient, who worries about all affairs, who may nerve himself or herself up to the bearing of the operation—now not a great task since cocaine is used,—and then lose all self-control immediately after the operation is finished, and be unable to sleep or eat until all hope of the eye is gone.

I recall three striking cases of loss of eyes in such temperaments. In all of them the operation was perfect in technique. In the two latter cases every aseptic precaution had been exercised. In the first case, which was before the days of aseptic surgery, immediately after the operation, the patient began to shake her head and to move about the bed. All remonstrances were vain, she would not be quiet or control herself at all, and suppuration occurred within twenty-four hours, with complete loss of the eye. In the second case, a gentleman of intelligence and education and social position, had been waiting for an operation for fifteen years, or, at least, had been waiting for a cataract to ripen so that he might have the operation performed. As he had one good eye, still being able to read with it, I protested against his taking the risks of an operation, but he fairly insisted upon it, and it being perfectly justified, the eye being a good one and in apparently a good healthy subject, I extracted the lens. He also immediately after the operation, which he bore very well, showed great nervousness, and suppurative iritis set in, and within twenty-four hours his eye was lost. The third case was that of a rather ignorant woman, prematurely old at fifty-five years of age, who also bore the operation well, had no pain immediately after, but was very nervous and restless. She did not sleep at all for twenty hours after the operation. She was a dyspeptic. In her case suppuration, also in the iris, set in in about fifty-six hours afterward. Most frightful panophthalmitis followed, through which she nearly lost her life through exhaustion.

The surgeon must make his prognosis, and then proceed somewhat according to the temperament of his patient. A case will not necessarily do well because the patient is in fairly good health or necessarily do badly because his health is feeble. It is to be remembered that cataract is recruited from people who are not physically strong and the continued waiting for blindness, is enough in many cases to completely unnerve the system.

As I have intimated in other parts of the volume, I am a great believer in the effect of constitutional conditions upon local parts. The more I practise, the stronger I come to the conclusion that there are many factors beside the local ones, to be considered in the treatment of disease.

Of late I am giving patients, upon whom I operate for cataract, fifteen or twenty grains of sulphonal in warm water, about three hours before the ordinary time for retiring, in order to quiet the nervous system, not at all as an anodyne, and thus far

I am well pleased with the results. I think I have averted dangers in some nervous patients by the use of this drug.

I find scopolamine quite as efficient as atropine in the treatment of iritis after extraction of cataract, and I now use a solution of the hydrobromate of scopolamine, one grain to the ounce, in cases with great suppuration. I do not know that it is any better than atropine, except that it dilates the pupil more promptly, and this may be an important consideration in many cases.

Dr. W. H. Smith, house physician to the Manhattan Eye and Ear Hospital, at my suggestion, took the temperature of eighty-one consecutive cases of operation for cataract. My object was to learn if an increase or depression of normal temperature indicated anything in the progress of the case. A careful study of these details showed me that an increase of temperature always indicated some inflammatory disturbance in the eye, and that it is of some value as indicating what is going on before the bandage is removed. If I should see the temperature at all elevated in the course of recovery from a cataract operation, I should expect some iritis or capsulitis. If it were, on the other hand, depressed, it would indicate failure of nutrition, and I should stimulate such a patient. These details will probably be published in full in the Report of the Manhattan Eye and Ear Hospital, but their general indications may be found in what I have said. I, therefore, think it of considerable importance to note the temperature twice a day after an operation for cataract.

OPERATIONS FOR SOFT CATARACT.

The operations for membranes in the pupil have already been described. But there remain a few words to be said in regard to the operations for soft cataract, and the treatment of traumatic cataract. In the total soft cataract of childhood and infancy, discission should be practised at an early period. The first incisions with the needle should be delicately made, and the subsequent ones be regulated entirely by the grade of the reaction. Children's eyes should not be bandaged after these operations, but they should be kept in semi-darkened rooms with their eyes shaded, atropia or scopolamine instilled, and cold applications made according to the pain, redness, swelling of the

lens, and so forth, the hands of the little patient being confined so that it cannot reach its eyes. The pupil is to be kept well dilated, and if too much lens matter escape and the eyeball become hard (secondary glaucoma), it should be evacuated by linear extraction. In some cases of soft cataract, after needling, the anterior chamber becomes filled up with lens matter as soon as the needles wound the lens, which should at once be evacuated, as far as possible, by a linear extraction.

Traumatic cataract deserves a consideration by itself, because it is possible to save many an eye in which this injury has been done, if the proper precautions be taken. If, immediately after the accident which has produced the cataract, the opacity of the lens advances slowly, we may defer an operation, but if the lens swell, we must operate at once, by linear incision, by syringing, or suction. I prefer the latter method, but the high praise awarded the former procedure has led me to fully describe this operation, and to note its applicability to many cases of soft cataract section, to which syringing of the anterior chamber may be added (see Chapter X.).

For shrivelled lenses with thickened capsules, iridectomy, with, if necessary, an extraction of the whole mass by forceps, may be performed. Zonular and anterior and posterior polar cataracts seldom require an operation. If any operation is required, an iridectomy may be performed. The cyclitis likely to occur, may be deprived of serious effects by keeping the pupil well dilated with atropia or scopolamine and by the use of iced clothes and leeches. Sometimes it is only necessary to use atropia, and at others all the agents for subduing iritis will be needed. But just as in soft cataract after discission, if the lens swells very much and masses protrude into the anterior chamber, they should be removed.

A fuller discussion than was allowable in the chapter on operations, will be undertaken in the next chapter, in regard to the character of the incision made in the extraction of cataract.

CHAPTER XXIV.

CATARACT (*Concluded*) — DISLOCATION OF THE LENS.—LENTI-CONUS.

The Shape of the Flap in Extraction.—Linear Wound Heals More Easily than a Flap.—The Different Sections from the Time of Daviel to the Present.—Teale's Method.—Conjunctival Flap.—Removal of Lens in its Capsule.—History of the Operation of Extraction.—Mr. James Ware, Percival Pott, Baron de Wenzel.—Glaucoma after Extraction of Cataract.—Glaucoma Occurring during the Formation of Cataract—The Operation of Suction for the Removal of Cataract.—Heredity in the Development of Cataract.—The Statistics of the Results of the Operation.—The Author's Own Results.—Dislocation of the Lens.—Agnew's Method of Extracting Dislocated Lenses.—Lenti-Conus.

THE history of the operation of extraction of cataract, like most great advances in any science, is exceedingly interesting. It is generally conceded that François Daviel, was the first to recommend and practise extraction by what is called the "corneal flap." This was in the year 1747. In the language of Stellwag, "he is the famous founder of the modern technique in the operation for cataract." He has had a happier fate than most of the distinguished surgeons of the world, since a statue has been erected to his memory. We can almost count on the fingers of our hand, the statues to medical discoverers in the civilized world. It is true, that among the Arabs and Persians and in the seventeenth and eighteenth centuries, cataracts were extracted by German and French surgeons. As far as can be determined, they used needles, hooks, and forceps in order to remove the lens from its position, and take it out of the eye. But the procedures were so severe, that they never came to any general acceptance. Daviel, opened the anterior chamber from the lower scleral border, with a knife curved on the flat, and enlarged the wound on both sides with a double-edged knife. Then he introduced curved scissors between the cornea and the iris, and, always adhering to the limbus, he made a flap which was nearly two-thirds of the cornea, and whose base was a little

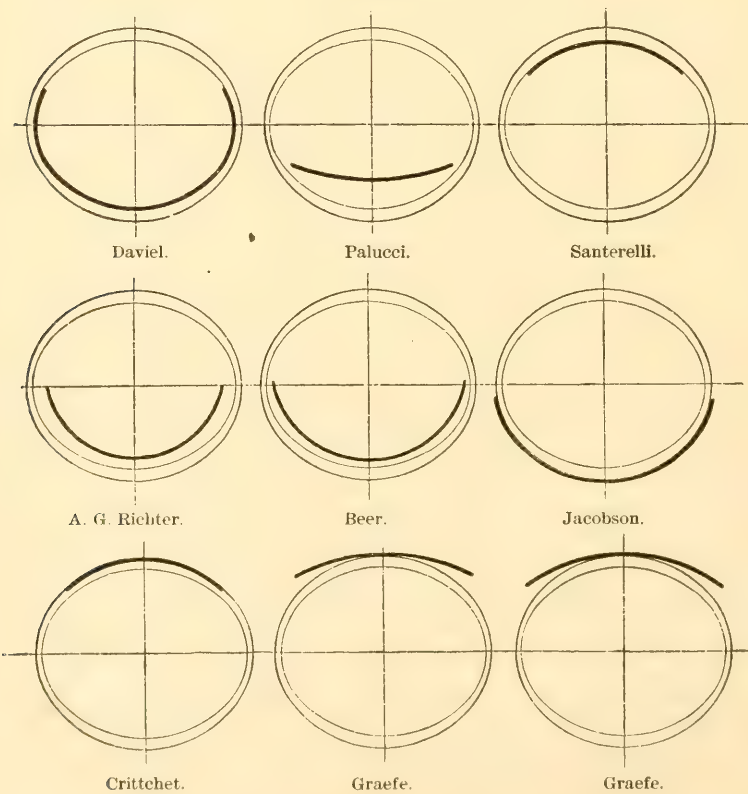
above the pupil. This flap was turned over by means of a spatula and the anterior capsule was divided by a sharp needle, and, in case of necessity, a circular opening made, so as to be able to draw it out with the forceps. The lens was taken out by a spatula, shoved under its upper border with slight pressure. After the flap was replaced in its normal position, the cataract was extracted by the gentle pressure of two fingers on the lower portion of the anterior zones of the sclera. The cortical substance was removed with a curette. Of 260 cases, Daviel records 182 favorable results—not as good a percentage as can be obtained now. It is to be remembered, however, that the tests were by no means as exact as now, and mere ability to get about and see large objects would perhaps be considered a "favorable result." A few years after, Pallucci endeavored to simplify the procedure. He made the cut in the flap with a peculiar needle, cutting at its neck, which he entered deep under the oblique diameter of the cornea, near the scleral border, and then pushed it out. The flap is a very short one. Its border was, at least, two millimetres from the edge of the cornea. Pallucci also enlarged the section with scissors. The cataract was removed by pressure on the globe. I have quite often had occasion to enlarge the incision in the cornea with scissors, and I do not think such an enlargement militates at all against the success of the operation. While writing these lines, I have seen an old lady of eighty-four, in whose case I was obliged to make such an enlargement a year ago, when I extracted a cataract. This patient had had a preliminary iridectomy, and although she had a severe and tedious iritis, the result is most excellent. Her vision is $\frac{20}{30}$. She reads the finest type with ease, and has done so for nine months.

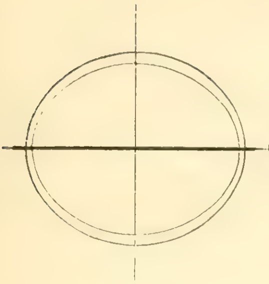
Returning to the history of this operation, we observe that A. G. Richter opened the cornea with his straight-pointed cataract knife with a convex cutting surface. He divided the capsule thoroughly in all directions in order to avoid membranous cataract. Beer, in 1817, laid down the principle, that the corneal section must, in the first place, be sufficiently large, so that not the slightest hindrance can come to extracting the lens from the eye, and he thought it only large enough when the half of the cornea, as near as possible, is opened on its border. In the sec-

ond place, he insisted that it must have a good shape, and this consists in having the lips of the wound well rounded.

It was Beer's knife which was used, with very little modification, until Graefe's narrow knife was invented. It is a much more difficult knife to manage than the narrower ones, as those of us who began to operate with it, bear in vivid remembrance. Daviel operated with his patients in the sitting posture, and I saw Junke operate in the Berlin clinic in this way, in 1863. Mooren, in 1862, endeavored to avoid the dangers from the mechanical irritation of the iris, and the remaining behind of pieces in the extraction of the lens and of the cortex, by preceding the cataract extraction with an iridectomy, at least fourteen days before. Jacobson finally united the iridectomy with the extraction of the lens.

SECTIONS FOR EXTRACTION OF CATARACT FROM THE TIME OF DAVIEL.

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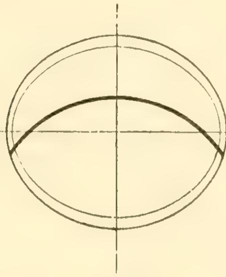
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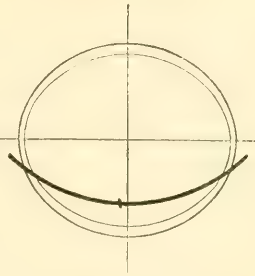
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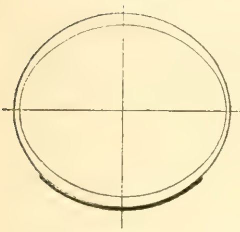
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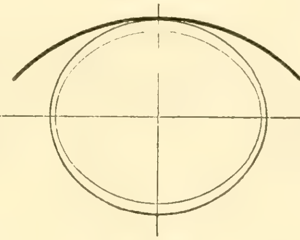
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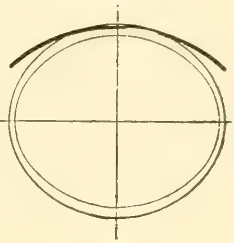
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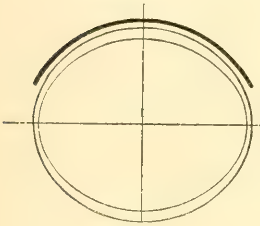
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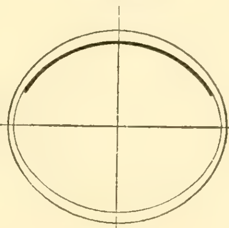
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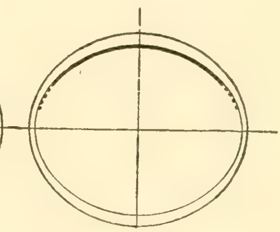

Stellwag.

A study of the different attempts to improve the operation for extraction of cataract since the time of Daviel, is most interesting. The figures here given, taken from Stellwag's monograph,[1] show these changes very graphically. If suppuration depends on the size of the flap, then Daviel's flap would seem to invite it, and yet his statistics of results were fairly good, although I am not able to say how many of the failures were due to suppuration. It will be observed that Daviel, Palucci, Richter, Beer, Weber, and Liebreich, made sections in the lower part of the cornea. Such sections are, I believe, universally abandoned, and for good reason. The danger to the

[1] "Neue Abhandlungen aus dem Gebiete der praktischen Augenheilkunde," page 214.

edge of the wound from inverted lids and cilia is very considerable. Cases have been lost, from the rubbing of the lids on the lower section. I believe, by general consensus, we have come down to about such incisions as those of Wecker and Stellwag. It was a colossal error of Graefe's, distinguished as is his service in Ophthalmology, to make a linear incision at all involving the ciliary region. This was to invite sympathetic irritation, and so it proved. More eyes were lost from sympathetic irritation during the days when this operation was being generally performed, than at any time before or since. Mr. Teale, the veteran surgeon of Leeds, lays great stress on a linear section, as has been intimated, and the drawing of his method presented on this page, illustrates this very well. This section is made with a narrow knife, almost identical with Taylor's, marked No. 822 in Weiss' catalogue. I do not think that this knife is necessary, but I think that the principle of a small flap, without an iridectomy, is a good one.

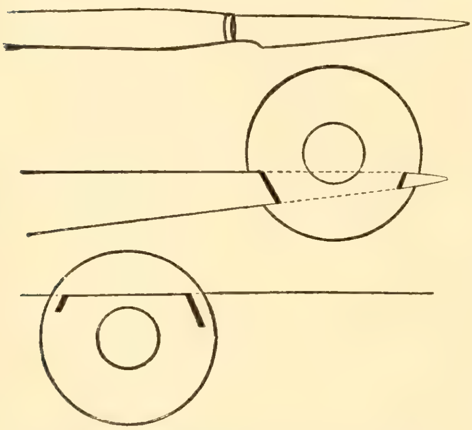


FIG. 159.—SHOWING TEALE'S KNIFE AND SECTION, IN THE EXTRACTION OF CATARACT.

I am persuaded that the best operation in most cases is an upward section, not too large, but large enough to admit the easy escape of the lens, not too close to the margin, lest prolapsus of the iris occur, and without iridectomy. Dr. Webster, of the Manhattan Eye and Ear Hospital, prefers to make a conjunctival flap. To this I have no objection, although I do not think it essential. But I earnestly warn young operators against an incision involving the ciliary region, from the danger of sympathetic irritation and prolapse of the iris. Although I have given up the general use of my operation of removal of the lens in its capsule, I still think it applicable to a certain class of cases. Especially is it useful where unmanagable patients of intemperate habits, are pretty sure to have severe iritis after a

cataract extraction. If, in such cases, we can remove the lens in its capsule, even if we lose a little vitreous, we stand a better chance of saving the eye and giving good sight, than if severe iritis and incarceration of the iris, as they are apt to occur in such subjects, finally block up the pupil, and, after a long period of inflammation, cause the loss of the eye from irido-choroiditis.

I have just involuntarily removed a lens with its capsule in the case of a woman, who had no control over herself. The moment the section was finished, she snapped her eyes together with great force, extruding the lens in its capsule with a portion of the vitreous humor. She made, however, an exceedingly good recovery, with a clear, black, and large pupil, the iris being turned under as it is apt to be in this operation. In such cases as this, cocaine fails to be an efficient local anæsthetic, but anything would fail with such patients. I have had similar ones where, anticipating trouble, I have performed a preliminary iridectomy, had the patients drilled in the technique of the operation, and yet at last, unable to control themselves, they pushed out the lens. I have observed that the flaps in the cases of extraction of the lens with the capsule, heal much less readily than those of ordinary simple extraction. This is probably due to the fact, that the iris is pushed a little out of place, when the lens emerges, and that this assists in causing the wound to gape. The bandage is needed longer in this case, than in simple extractions. I gave up this operation for general performance, because the advantage of avoidance of pupillary membrane was not secured, or, at least, membranes sometimes formed in the anterior part of the vitreous, which were quite as troublesome.

All observers agree that a flap operation, that is to say, the flap of good size, allows the lens to escape more readily, but that a linear wound heals more easily and with greater rapidity. This speaks for Teale's and Liebreich's operations, the former of which is almost linear, and the latter approximates it. So long as the linear wound is not made in the sclero-corneal juncture, I am very much in favor of this approximation to such a shape, and an avoidance of a large flap. This can be accomplished by turning the edge of the knife upward, and cutting out pretty rapidly.

Mr. James Ware, the famous London surgeon, who added to our knowledge the statistics of myopia in Great Britain, as long ago as 1801,[1] very strongly advocated extraction instead of depression of cataractous lenses and discission in the soft cataracts of young persons. It is remarkable that reclination continued to be practised in such medical centres as New York and Philadelphia, until about 1850, when Daviel in the middle of the eighteenth century, and Ware at the very beginning of the nineteenth, so earnestly urged extraction upon the profession. It is interesting to note in Mr. Ware's remarks on the subject, that he says nothing of using any mydriatic after the operation, but the dressings seem to have been entirely without any such agent. In a few cases, where there is a susceptibility to belladonna poisoning, the surgeons of the present day are obliged to dispense with the use of atropia, or any mydriatic, for where an eye reacts unfavorably to atropia, it seems also to act in the same way to duboisia, homatropine, and cocaine. They are very much embarrassed, while the surgeons who had no mydriatics, seem to have secured very good results, after extraction, without them. But, as has been already said, the means for determining vision, have been rendered so accurate in modern times, that we cannot necessarily assume, because they speak of getting good results—the patient being able to see objects, count fingers, notice the color of things, and so forth—that they saw well enough to read. Baron de Wenzel, the reputed author of the famous apothegm, that "a man must spoil a hatful of eyes before he could save one," also recommended extraction in preference to reclination, while the celebrated Percival Pott, in 1775, argued for reclination. Mr. Ware concludes from his observations on cataracts, when children are born blind in consequence of having cataracts, they are never so totally deprived of sight as not to be able to distinguish colors, and he also shows, that whatever objects they could make out when they came within the distance at which they could see them, they could tell whether they were brought nearer to or carried farther from them. Mr. Ware found also that the congenital cataracts were usually soft.

I have never treated but one case of extraction of cataract, absolutely without a mydriatic. In this instance, that of simple extraction in an old man, the eye was so entirely without inflammatory reaction on being opened on the seventh day, that I concluded, although there was soft lens matter in the pupil, not

[1] Transactions of the Royal Society, 1801, p. 382.

to drop anything in the eye, lest I might set up an irritation. The patient made a perfect recovery, the lens matter was completely absorbed without any secondary operation, and without the use of any mydriatic whatever.

SUCTION IN CATARACT.—Dr. Lucien Howe[1] goes so far as to even recommend suction in removing a lens, for which the corneal wound has not been made large enough. In certain cases of this kind, he takes an ordinary drop tube, changes the curvature of the end and enlarges it. Latterly he had them blown, with an opening sufficiently narrow in one direction and long in the other to enable these points to fit somewhat exactly upon the edge of the partly projecting lens. A piece of thick rubber tubing is fastened to the glass tube, and the other end is held between the lips, while the glass point is attached to the lens. The globe of the eye is drawn down with the left hand, and the tube is applied to the lens with the right. With proper suction, Dr. Howe says that the projecting portion is at once engaged in the mouth of the tube, and very slight traction is necessary to remove it, compared with the pressure usually exerted on the cornea for this purpose. I agree with Dr. Gruening who said, in the discussion of this subject, that if the section is too small, it should be enlarged. An enlargement of the section is by no means attended by any danger to the eye.

Dr. Mathewson, of Brooklyn, recommends, in cases where the nucleus does not readily escape, that an assistant with a double hook rotate the lens from one edge to the other.

Dr. Valk (New York) uses a variety of spoon, an iris retractor to keep the iris back while the lens is forced out.

All these various suggestions, each of them having some value probably, in the hands of their inventors, show that in the operation for cataract many conditions may occur which will need considerable ingenuity on the part of the operator, in order to successfully overcome them. However many times the surgeon may have operated, he will find that conditions of embarrassment may occur in certain cases which will require means which he had not before thought of, in order to insure a safe evacuation of the lens. It is amazing what difficulties may occur in an operation, and yet be successfully overcome, and a good result follow, while, on the other hand, it is also surprising that operations performed under the most favorable circumstances, with the most careful technique, as has been before intimated, will sometimes fail to secure a successful result.

[1] Transactions of the American Ophthalmological Society, 1893.

GLAUCOMA AFTER EXTRACTION OF CATARACT.

Among the deplorable mishaps which may possibly, but, fortunately, not often, occur after extraction of cataract, is glaucoma. This subject has been alluded to in the discussion of this disease, but it should now be more fully considered as one of the possibilities after an extraction.

Sir William Bowman[1] in 1865 says that glaucomatous tension is particularly apt to come on after needle operations following flap extraction, where the pupil is small, and disposed by the integrity of the sphincter muscle, to remain small afterward, as well as to suffer at the moment from the dilating force of the needles.

Graefe, in 1869,[2] says that glaucoma after cataract, is due to the swelling of remnants of cortex in the anterior chamber, which irritates the posterior surface of the iris and ciliary processes, especially if the pupil is small, and also, there may be, Graefe continues, displacement of the capsule, with traction and irritation of adherent ciliary processes, especially when the capsule is tough and opaque, or has opaque stripes.

Priestley Smith summarizes the process as follows: The lens is removed without rupture of the suspensory ligament and capsule; plastic iritis, possibly due to the retention of cortical fragments, sets in, and the iris adheres throughout to the suspensory ligament and capsule. These membranes and the opening are coated over with lymph. A thick, impervious partition is thus created between the aqueous and vitreous chambers, the tension increases in the vitreous, the angle of the anterior chamber is closed, a certain amount of turbid fluid is imprisoned in the anterior chamber, intense glaucoma rapidly occurs.

Collins,[3] after a study of ten cases, concludes that the adhesion of the capsule of the lens to the scar in the cornea, afte extraction of cataract, strongly predisposes the eye to glaucoma. In some cases, this adhesion, combined with an entanglement of the iris, is sufficient to light up an attack.

Of 1,405 senile cataracts extracted at Moorfields Hospital, in

[1] Ophthalmic Hospital Reports, vol. iv., p. 365.

[2] Ophthalmic Hospital Reports, vol. viii. (translation).

[3] Transactions of the Ophthalmological Society United Kingdom, vol. x.

London, from 1885 to the middle of 1889, nine were lost from glaucoma, or 0.64 per cent.

I have operated upon three cases where glaucoma occurred in the course of the development of senile cataract, but not as the result of an operation.

HEREDITY IN CATARACT.

Heredity is an important factor in the formation of senile cataract.[1] I have operated upon father and daughter, and cousin of the father, in one family, and an aunt of the cousins was operated upon by another surgeon, while another cousin had senile cataract, but he died before the time set for the operation. I also know of a nephew, a man between fifty and sixty years of age, who is now affected with incipient senile cataract. In still another family, I operated upon the father and two sons. And these instances can be repeated in the practice of every surgeon who has seen much of ophthalmic disease.

Two other cases, brothers, in whom I have now operated upon both eyes, are remarkable, because they are both undersized men, with good mental capacity however, and microphthalmic. Their eyes as to the cornea certainly, and apparently as to the eyeballs, are about half the size of ordinary adults, even of those below the medium size. The lenses bore no such disproportion in size to those of ordinary eyes, as did the cornea. They were comparatively large. The vertical diameters of the second brother's corneæ is 6 mm., the horizontal only 7 mm. That of the older is not greater.

Priestley Smith,[2] after examining 500 eyes, 250 males and 250 females, gives "the healthy cornea of the living eye of persons between five and ninety years of age an average horizontal diameter of 11.6 mm."

The first brother, Floyd P., was 28 years of age when I operated upon the right eye, October 22, 1880, after vainly attempting to produce absorption by needling the lens. Making no impression upon it, I removed the lens by Graefe's method, and good vision resulted. Later, in November, I operated upon his fellow-eye, also successfully,

[1] Archives of Ophthalmology, vol. xx., No. 2, 1891, pp. 230-232.

[2] Transactions of the Ophthalmological Society of the United Kingdom.

and in February, 1889, upon his brother's eye, and finally, in January, 1891, upon his fellow-eye.

All of the operations have been successful, but all have required secondary operations except the last. The second brother had a diffuse opacity of the upper part of the cornea, which disappeared in ten days after, under the use of calomel. I am inclined to think that this opacity was due to the too prolonged use of cocaine, as he was very timid and insisted on having a great deal used.

RESULTS OF THE OPERATION.

It is undeniable that the proportion of successful cases in a given number of cases of senile cataract has increased notably in the last twenty-five years. While Horner's statistics may be a little too flattering (Horner makes $97\frac{2}{7}$ per cent of successes), it may be safely stated that about 90 per cent of cases carefully selected for operation, as affording a good prognosis, will furnish good results. If cases are taken just as they come, and every one operated upon that offers the slightest hope of success—which is proper action on the part of the surgeon, for the patients remain blind without interference—the proportion is not nearly so high, but even then, judging from 251 consecutive cases occurring in my own practice, where many should have been excluded, if only those affording an excellent prognosis were operated upon, 217, or 86 per cent, received useful vision as the result of the operation. A substitution of cocaine for ether or chloroform, in operating, the removal of many of the unnecessary restrictions on the patient, and the knowledge of antiseptic precautions, are the factors which have produced this advance in surgery, and made the prognosis so good in such a large proportion of instances. Yet, under the most favorable circumstances, as has been shown in the preceding pages, an eye may be lost, while under untoward ones vision may be restricted. There is no field, however, in surgery which offers more brilliant results than this of extraction of cataract, and nowhere besides perfect technique in the operation, will great experience and good judgment in the after-treatment, be of more avail. Experienced operators continue, as in the time of Baron Wenzel, to be the best operators.

DISLOCATION OF THE LENS—ECTOPIA LENTIS.

(ἐκ, from; τόπος, place.)

This may be a congenital affection, in which case it is usually only partial, and the same condition exists in each eye. Sometimes a congenitally dislocated lens is also cataractous. In this case, it is probable that the dislocation is the result of the partial absorption of the lens. In adult life, a traumatic cataract unremoved is apt to end in dislocation of that part of the lens that is not absorbed. Partial dislocations or displacements may occur.

A case of this kind in my practice was that of a man of 34, in whom the lens was displaced by a blow or scratch from a finger-nail on the temporal side of the cornea. Slight pain and inflammation followed. When these subsided, the patient found his vision blurred, and he had monocular polyopia. "Street-lamps looked like comets." His vision was $\frac{20}{200}$. With -1.20 it became $\frac{20}{70}$. His far-point for No. 1 Jaeger was 7 inches, near 4 inches. In the fellow-eye, $V = \frac{20}{20}$ $\frac{1}{P} - \frac{1}{R} = \frac{1}{S}$. The pupil of the injured eye was contracted and sluggish. Under atropia R. E. has $\frac{20}{50}$. -136 removes the blur, but does not enable the patient to see any more letters. The ophthalmoscope show an opacity of the nasal side of the lens, and a tipping of the lens. Eighteen days after, the patient having used atropia daily for ten days, he found that he had suddenly recovered his distant acuteness of vision. Six months after I examined his eyes and found $V = \frac{20}{30}$, and the patient stated that he had had no trouble since the Christmas morning after the accident, when he found that the blur was gone.

Astigmatism is said in the notes to have existed, but no cylindric glass improved it.

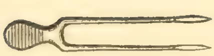
Dislocated lenses usually become cataractous, but in some cases they remain transparent. I have known one lens, in a case of double dislocation, to become opaque while the other remained clear. This refraction is variously affected by dislocation of the lenses. In congenital cases the lens usually lies out of the visual line, when of course the refraction is highly hyperopic. One of my little patients of this class wears a glass over each eye of plus seven diopters. Dislocated lenses very often act as foreign bodies, and cause choroiditis, with utter loss of vision. The diagnosis is not always easy, but it is generally so.

The tremulous iris is never absent in complete dislocations. The lens may lie in the anterior chamber. In rare cases it is dislocated under the conjunctiva. This occurs when a severe blow has ruptured the sclera and left the cornea uninjured.

Treatment.—When the lens is producing inflammation, it should be removed. This is sometimes difficult, and various operations have been invented for this removal. One of the difficulties in the way of a successful extraction of the lens is, that on patients lying down, it may fall so far back into the vitreous that it cannot readily be got out. The vitreous is lost in such quantity that removal of the eyeball is necessitated. If the lens do not show this mobility, but remains in position, when the patient is lying down, the simple operation of making a good flap in the cornea, and then removing the lens with a spoon or a curette, furnishes no particular difficulty. Several operators record successful removal of a floating lens by causing the patient to hang his head, face downward, over an operating table, while the surgeon worked from below.[1]

AGNEW'S OPERATION FOR REMOVAL OF DISLOCATED LENS.

Agnew's operation and instrument, the *bident*, are especially adapted, and have been successfully employed by Agnew, Web-



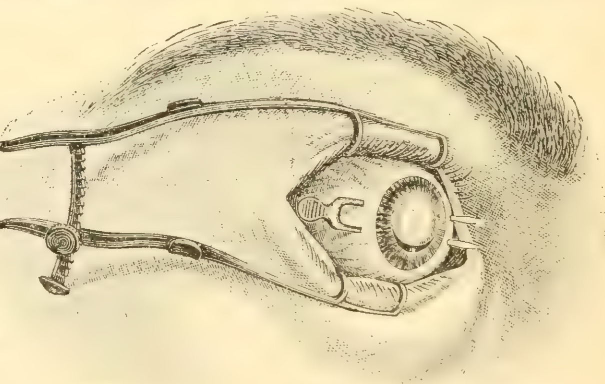


FIG. 160.—AGNEW'S BIDENT.

FIG. 161.—AGNEW'S BIDENT IN THE EYE.

ster, Lewis, and other operators in many cases. Dr. Agnew says,[2] in his article on the bident, that to remove a dislocated lens from the vitreous humor and save the eye "is more difficult

[1] H. W. Williams, H. D. Noyes, and others.

[2] Transactions of the American Ophthalmological Society, 1885.

than any other operation in ophthalmic surgery." The bident consists of two fine, straight, delicately pointed cataract needles, each six-eighths of an inch long, fixed parallel to each other, at a distance a little less than one-eighth of an inch apart. They are united by a flat handle, so that the instrument can be held in a needle-holder. The instrument in the needle-holder is pushed into the vitreous humor, far enough back to avoid wounding the iris or touching the lens, but when the bident has well entered the eye, its handle is depressed and the lens lifted upon it, "as a pen might be lifted on a two-tined fork." The bident is then pushed forward, and caused to emerge on the nasal side. The lens resting securely upon the fork, the cornea is opened and the lens removed with a spoon. In one case Dr. Webster was obliged to remove the bident before he could remove the lens, although in some cases enucleation must be resorted to, in a dislocation of the lens, and in others the removal of the lens is only followed by severe inflammation which necessitates subsequent enucleation. Yet enucleation should never be advised for a dislocation of the lens when any considerable vision remains. My colleague, Dr. Frank N. Lewis, has just removed a dislocated lens with the bident very successfully, and by the operation so reduced the myopia, which was excessive, as to markedly improve the vision. The objections made to the bident, by good authorities, seem to me purely theoretical. The instrument is a valuable resource in certain extreme cases, when it is pretty certain, that the lens cannot be extracted by a simple section and the use of a spoon or hook. I have successfully used a cystotome in one case. The wound made in the sclera by the bident, is a real objection to its use, because such an incision may possibly cause sympathetic irritation.

Congenital dislocation of the lenses is not uncommon. I have now under observation a boy of eleven years of age, whom I have seen regularly since he was four, who was born with a dislocation of both lenses, upward and outward. They are not floating about, but remain fixed. That of the left eye is becoming somewhat opaque, and I hope it may be extracted at some future time. He is able to read the finest type with a $+12$ D. spherical glass, and he has vision, V. $= \frac{20}{70}$, at a distance. He seems to have absolutely no accommodation.

Dr. Lewis H. Taylor[1] reports a case of a young man of twenty whose lenses are both symmetrically dislocated upward and outward, about one-third of the diameter of each being visible beyond the pupillary margin. The lenses were partially opaque. His vision is $\frac{20}{70}$ with correcting glasses. Dr. Taylor discusses the question as to whether an accident, which occurred to the mother during pregnancy a week before the birth of this son, when she fell forward, striking heavily on her abdomen, had anything to do with the dislocation of the lenses. In my case, the child was delivered by forceps, and I think it quite possible in all such cases that the dislocation of the lens may have been caused by the traumatism. Dr. Taylor quotes Professor Jaeger as giving an opinion of two cases of dislocation of the lenses—that one was congenital because both lenses were displaced inward and upward, and another was regarded as probably traumatic, because both lenses were displaced upward and to the left, that is, one outward and one inward. In a certain sense, I believe all these cases, whether congenital or not, can ultimately be traced to an injury, and are, therefore, traumatic.

Dr. W. S. Little[2] reports two cases of supposed congenital dislocation of the lenses. The first one was non-symmetrical, the displacement being upward, but with both lenses to the left. In the second case, the displacement was symmetrical, both being downward and inward.

The treatment of dislocation of the lens, of congenital origin, depends entirely upon the vision which can be secured without operation. If that can be made fairly good, the operation ought to be postponed until positively indicated.

LENTI-CONUS.

This condition of the lens, which is probably congenital, is that in which there is a protuberance from the anterior or posterior surface. It is, therefore, described as anterior or posterior lenti-conus. It has been only rarely observed. There are, however, five cases on record. The first case was by Webster,[3]

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[1] Journal of the American Medical Association, Nov. 4th, 1893.

[2] Transactions of the American Ophthalmological Society, 1883.

[3] Archives of Ophthalmology, 1875.

and was one of anterior lenti-conus. The second was reported by Van der Loan and Placido.[1] The third was by F. Meyer[2] and was the first case of posterior lenti-conus observed. The fourth was by Knapp,[3] and the fifth by Weeks.[4]

I had an opportunity of seeing the case reported by Dr. Weeks, he having exhibited it at a meeting of the New York Ophthalmoscopical Society.

It occurred in a child of seven years, who had convergent strabismus, and who came to Dr. Weeks for the correction of that defect. There were remnants of the fœtal pupillary membrane in the right eye. In other respects it was normal. In the antero-posterior axis of the left eye was seen, with the ophthalmoscopic mirror, a bright round patch, thought to be, by Dr. Weeks, about 4 mm. in diameter. It was situated between the iris and the fundus. The centre of the lens was of myopic refraction, the margin hyperopic. The projection was on the posterior surface of the lens. There was an opacity at the apex of the cone, which Dr. Weeks thought was due to the remains of the fœtal vessels.

While writing this chapter it has been my fortune to see a case, making six in all, of this condition that have been reported, shown to me by Dr. Frank N. Lewis. The patient came to the Manhattan Eye and Ear Hospital, and a description of his case is here given:

John O'G., a roofer, 21 years of age, always been well and strong, accidentally noticed, about eight months ago, that the vision of the left eye was very poor. He never had had any pain or inflammation of the eye. The examination showed V.R. = $\frac{20}{30}$; $\frac{20}{20}$ with +.50 ⌒ +50c. 90° and Jaeger No. 1. V. L. = $\frac{2}{200}$; $\frac{8}{200}$ with +3 ⌒ +1c. 90° and unable to read Jaeger type. The right eye showed no changes in the media or fundus. The left eye showed nothing abnormal externally, the movements of the eyeball good in all directions; the iris normal, pupil normal and reacts well to light. On looking into the eye with the ophthalmoscope from a distance, there appeared a bright round spot, a little to the temporal side of the centre, which looked much like a drop of oil on water. On moving

[1] Period. of Ophthal. Lisboã, 1881.

[2] Hirschberg's Centralb. f. p. Augenhl., Bd. xii., p. 41.

[3] Archives of Ophthalmology, vol. xviii., p. 453.

[4] *Ibid.*, vol. xx., p. 260.

the mirror there was a distortion of the reflex from the fundus, and any vessel seemed to undergo a circular-like motion. About the margin of the spot, there was a dark crescentic shadow, varying according to the position of the eye. The spot was perhaps 3 or 4 mm. in diameter. At the centre of the spot was an opacity somewhat star-shaped, of sufficient size so that the details of the fundus could not be well seen through it. The rest of the lens was perfectly clear and through this the eye was hypermetropic. On examination of the spot with a + 23 D. glass behind the ophthalmoscope, the opacity was clearly seen, and the relation of this spot to cornea and iris, when the eyeball was moved, showed it to be posterior. In other words, there is a protrusion of the lens at this point, which is clear except on the apex.

Becker made an examination of a case of lenti-conus occurring in a rabbit. In this case, Becker concluded that the concentric lens fibres, the products of the third period of development of the lens, did not join at the posterior pole, but that they formed around the elongated nuclear fibres of the second period of development of the lens, and that these latter extended beyond the concentric layers and thus formed the cone.[1]

Weeks thinks it is easy to understand the formation of anterior lenti-conus. In embryonal life, the lens has only to become unusually adherent to the posterior surface of the cornea, for a little traction to cause it. Persistent fœtal vessels, which were observed in two cases, as also suggested by Weeks, may have produced traction sufficient to induce posterior lenti-conus in these instances. Very fortunately lenti-conus usually occurs in one eye only. If a case be observed when both eyes are affected, and the vision is as poor as in the cases reported, extraction of the lens, is to be considered as a means of improving the sight.

[1] "Anatomie der gesunden und kranken Linse," 1883, p. 126.

CHAPTER XXV.

DISEASES OF THE ORBIT.

Close Relations of the Orbit with the Nose.—Maxillary Antrum, and Cranial Cavity.—Injuries or Diseases of the Frontal Sinus.—Emphysema.—Hemorrhages.—Abscess.—Orbital Cellulitis.—Inflammation of Tenon's Capsule.—Periostitis.—Caries and Necrosis.—Aneurism.—Bony Growths.—Dr. Lewis' Case.—Exophthalmic Goitre.

THE orbit has close relations through its membrane and vessels with the nose, antrum, cranial cavity, and temporal fossa. Its diseases therefore are not altogether independent, and are not usually limited to a single tissue, but they are thus classified for the sake of convenience. The symptom common to many orbital diseases is exophthalmos, or protrusion of the eyeball. It may be hardly perceptible, or so severe that the lids cannot close, and the cornea, exposed to the air and injuries, sloughs and allows the contents of the eye to escape. Rarely, the globe may be forced entirely out and lie upon the cheek. With protrusion there is redness, and œdematous swelling of the conjunctiva and lids, the mobility of the globe is interfered with, and the nerves may be paralyzed from pressure. The vision is impaired according to the tension and pressure upon the optic nerve and ocular tunics.

INJURIES.—These are generally due to incised or punctured wounds, or to foreign bodies. They may cause orbital abscess, periostitis, hemorrhage, emphysema, fracture of the bony walls, injury of the eyeball, and even extrusion of it. The results may appear at once, or not until some time after the accident. Fractures of the roof and inner wall are very dangerous from injury to the brain. Foreign bodies should always be removed if detected. The best place for incision, either for exploration or for removal, is through the conjunctiva between the eyeball and lid. The outer canthus may be divided to give more room for manipulations. The parts should be kept at rest, and cold

cloths and leeches used to check any inflammation. If the eye is extruded it may be replaced, and the compress bandage applied. Incised and punctured wounds are treated as those occurring in other parts, by complete rest, protective bandage, atropia, and so forth.

Disease of the Frontal Sinus.—Pressure upon the orbit, with a tumor at the upper inner angle, and displacement of the eye downward and outward, is sometimes caused by distention of frontal sinus. The tumor, if left to itself, may burst into the nose, the orbit, or through the upper lid. Such cases should be carefully examined, explorative incisions made, until a diagnosis is secured. They are then to be treated by thorough drainage and antiseptic applications, such as the bichloride of mercury, in solution one to twenty thousand parts.

Emphysema.—This usually occurs from a fracture of the ethmoid cells or frontal sinus, or rupture of the lachrymal sac. Air enters the cellular tissue of the orbit and lids, and causes an elastic, crepitating swelling, and exophthalmos. It generally disappears under gentle pressure, by means of a flannel bandage.

Hemorrhages.—These are chiefly due to injury. They are sometimes spontaneous, but they may be caused by straining. Ecchymosis may appear in the lids, and under the conjunctiva, some time after the accident. They may cause exophthalmos and injurious pressure. The best treatment is to assist absorption by cold compresses and firm bandages. Incisions may be made where symptoms are urgent.

Abscess — Orbital Cellulitis. — These are caused by wounds, foreign bodies, disease of the bone, cold, lachrymal disease, operations upon the eye, extension of inflammation from other parts, severe constitutional disease. The symptoms are almost always acute, and reach the crisis in from eight to fourteen days. The lids are red, hot, and swollen; there is intense pain increased by pressure against the globe; fever and perhaps brain symptoms. The exophthalmos is generally directly forward. The vision may be impaired from pressure on the optic nerve, which may cause engorgement and neuritis. When pus forms, fluctuation may be found behind the lids, and the abscess may burst through the lids or conjunctiva. The prognosis

should be guarded on account of possible necrosis, meningitis, and permanent injury of vision. In the early stages, local blood-letting, and iced cloths, may be indicated. If suppuration occur, poultices should be applied, and subsequently an incision made through the conjunctiva between the lids and globe. An exploratory incision is proper when in doubt about the existence of pus, and it is always better to use the knife too early than too late.

INFLAMMATION OF TENON'S CAPSULE.—This occurs very rarely. It may be caused by catching cold, strabismus operations, and ophthalmitis. It produces pain, swelling, and redness of the conjunctiva and to a less extent of the lids, with perhaps slight exophthalmos. Leeches and iced compresses may be used in the early stages. The inflammation of the capsule usually begins in the wound. It seems to be caused by insufficient care of the eye, that is, avoidance of the entrance of dirt, occupation on close objects, wind or smoke in the eye, and so forth.

PERIOSTITIS OF THE ORBIT is generally limited, and due to cold, injury, foreign bodies, or is secondary to inflammation of other parts. In the acute form, there is severe pain, and local tenderness on pressure against the bony wall; swelling and redness of the lids, and perhaps slight exophthalmos, generally toward one side; sometimes there is fever. Pus may form beneath the periosteum, and necrosis may result. The general treatment is that of cellulitis. In the chronic form, which is generally due to syphilis, the symptoms are less marked. The pain is apt to be worst at night. Nodes and exostoses may develop. The treatment should be that used for syphilis.

CARIES AND NECROSIS result from injury, periostitis, cellulitis, syphilis, tuberculous and scrofulous cachexiæ. These cause sluggish, œdematous inflammatory swelling of the lids, which points and discharges foul pus. A fistulous opening is indicated by unhealthy granulations, and dead bone may be felt by probe. Pus should be evacuated as soon as possible, and the opening enlarged when necessary, for the removal or escape of exfoliated bone. The sinus should be kept open and clean, until it can heal from the bottom. In the healing process there is apt to be cicatricial contraction of the lid, leaving marked ectropion.

True aneurism may arise from the ophthalmic artery or its branches, causing protrusion and pulsation of globe. The pain is generally slight.

Diffuse or false aneurism is much more frequent. It is caused by the rupture of the artery from injury or disease, with sudden escape of blood into the orbital tissue. It may supervene upon true aneurism. There is immediate pain and exophthalmos. The latter increases with redness and swelling of the globe and lids, and an elastic, pulsating tumor appears at the edge of the orbit. The pulsation is stopped by pressure upon the carotid; the whirring noise in the head is audible with or without the stethoscope. The only treatment for true or false aneurisms is by compression or ligature of the carotid.

Aneurism by Anastomosis.—This is a rare condition, generally congenital and found in children. Most often it is situated in the subcutaneous tissue of the anterior part of the orbit. It consists of a group of dilated vessels, forming an irregular, doughy tumor with pulsation and thrill. It is not much affected by pressure on the carotid. The best treatment is by subcutaneous ligature or electrolysis.

TUMORS OF THE ORBIT.

These are of the same kind, benign and malignant, as are found in other parts of the body. They may arise in the orbit or invade it from the eyeball or from neighboring parts. They cause exophthalmos and its injurious consequences. Malignant tumors are of more rapid growth than benign, and involve the general health. Tumors should be excised when there is any prospect of benefit from the operation—if possible without sacrificing the eyeball. It is often necessary, however, to remove the latter also, even when considerable vision remains to it.

Bony growths of the orbit may sometimes be removed without a loss of the eyeball. If they have not already caused optic neuritis, vision may not be impaired after an early removal. The mode of operating is by chisel and hammer, after dissecting away the conjunctiva and subconjunctival tissue. When attached by a pedicle, as they usually are, the removal is not difficult.

BONY GROWTHS IN THE ORBIT.

Bony growths in the orbit, although an important subject, has received comparatively little attention. Andrews,[1] Pooley,[2] Knapp,[3] Grossman,[4] Jones,[5] Adamük,[6] and Watson[7] also report cases, as shown by Dr. Frank N. Lewis in his paper on the subject.[8]

As will be seen from these cases, there has been much variation in the size, location, and readiness with which the growths have been removed. There is also much variety in their consistency. They have sometimes been rather soft, and then again, they have been as hard as ivory. In some cases they spring from a narrow pedicle, either from the frontal, ethmoid, or superior maxillary bone, while, in other cases, the attachment was broad and firm. The etiology is not at all clear, although traumatism is probably either a primary or an exciting cause to a more rapid growth of osteoma that already existed.

The following case came under my observation at the Manhattan Eye and Ear Hospital. The patient was transferred to the care of Dr. Lewis, who operated upon him, and removed the growth. The patient was a man of 27 years of age, a blacksmith's helper. He never had had any constitutional disease, according to his statement, and there was no evidence that he had. Eighteen months before the right eye was observed to be more prominent than the left. Two months before this he had been struck by a stone on the right mastoid process. The wound healed quickly, and there had been no trouble from that since. A few days before the right eye began to protrude, he was bitten on the bridge of the nose by a dog. This wound also closed quickly, and gave him no further trouble. There was no history of any other injury. But the eye gradually protruded, without pain, redness, or swelling of the lids or eyeball. The vision remained good until three months ago, when it began to fail. When he was admitted to the hospital, the vision on that side was $\frac{20}{70}$. The eye was pushed for-

[1] New York Medical Record, Sept. 3d, 1887.

[2] Transactions of the American Ophthalmological Society, 1890.

[3] Archives of Ophthalmology, March, 1888.

[4] Ophthalmic Review, December, 1887.

[5] Transactions of the Ophthalmological Society of the United Kingdom, 1888.

[6] Archives of Ophthalmology, vol. xix., 1890.

[7] Transactions of the Ophthalmological Society of the United Kingdom, 1889-1890.

[8] New York Medical Record, May 27th, 1893, p. 654.

ward, downward, and outward. The lids were scarcely red, there was a little lachrymation. The eyelids could be closed, and the motion of the eyeball was good in all directions, except upward, where it was somewhat limited. The cornea, lens, and vitreous were clear, and the pupil responded well to light. There was some swelling of the optic papilla, but the retina was clear, and there were no hemorrhages. A firm mass could be felt above and extending behind the eyeball. It did not give the impression of being very hard bone to the finger, but this was because, as was subsequently learned, the growth was very deep in the orbit. There was much soft tissue in

FIG. 162.—ORBITAL TUMOR IN DIFFERENT ASPECTS.

front. The patient was put under ether. Dr. Lewis operated. His description of the operation, and the subsequent progress of the case, is as follows:

"A free incision, one and one-eighth inch below the superior orbital ridge, was made, and extending from above the inner to a point outside the outer canthus. After dissecting down through the soft tissue, the hard, bony, irregular mass was reached, about one-half inch behind the orbital ridge. It was firmly implanted against the superior and inner walls of the orbit, and no well-defined pedicle was to be made out. The growth was removed with the chisel, and its removal was accomplished with much difficulty. It was attached by a broad surface to the frontal and the ethmoid bones, and a point of the growth extended to, if not into, the optic foramen. On removal it was found to be of ivory hardness, irregular in shape, with smooth surface. Its weight was thirty-one grammes, or nearly one ounce. The longest diameter was 45 mm. by 24 mm. On the inferior surface was a deep groove, which probably lodged the optic nerve, and from pressure may have been a cause of the neuritis, as this groove must have nearly encircled the nerve. The cavity was thoroughly washed and some small chips of bone removed. The wound was

closed with sutures and a drainage-tube inserted. The operation was done with thorough aseptic precautions. On recovering from ether, the patient vomited blood, and there also was blood coming from the nose on the right side, showing that there was a communication between the orbital and the nasal cavities, and this was also later shown in dressing the wound, as fluid could be forced through the drainage-tube into the nose.

"During the evening the dressings having become saturated with blood, they were removed. There was swelling of the lids and chemosis. On the following day, the patient having slept fairly well during the night, the dressings were reapplied. There was swelling of lids, and conjunctiva and eyeball still somewhat protruding.

"On May 16th, two days after the operation, the patient was taken with vomiting during the afternoon, and at 6 P.M. the temperature was 106.3° F., and pulse 128, irregular and intermittent. There had been no chill. There was no delirium and the patient very rational, but having some pain. Wound redressed, and in washing through the drainage-tube fluid passed into the nose. Hot applications were kept constantly applied. Morphine was given hypodermically, and patient was sponged with alcohol.

"From this time on the patient made a steady but slow recovery, the temperature gradually subsiding. There was much swelling and redness of the lid and destruction of the epithelium, but the deeper parts of the lid healed well. Some suppuration from the cavity in the orbit followed, but this gradually subsided. The eyeball did not become inflamed, the cornea remaining clear. The vision became much worse; two days after the operation there was only perception of light, and at the end of seven days there was no perception of light. Nine days after the operation there was some paralysis of the left hand, the patient being unable to close the fingers, but had good use of the arm and forearm. This paralysis lasted for three days.

"The swelling and redness of the lid gradually subsided and suppuration stopped. The communication with the nose remained for two weeks.

"The patient was discharged from the hospital June 27th, six weeks after the operation, and at this time the wound was well healed. The eyeball was still somewhat protruding downward and outward. There was ptosis and inability to rotate the eye upward or outward. The optic disc showed white atrophy.

"The patient has been seen since, the last time was in October, four months after leaving the hospital, and at this time there was less exophthalmos, although still very apparent. There was better mo-

tion of the eyeball and lid. A small sinus at the outer angle of the wound. Patient has no pain."

Dr. Lewis considers it very doubtful if the injuries recorded had anything to do with the exophthalmos. The size of the growth was an interesting feature. Placing the mass, after removal, in the orbit of a normal adult skull, more than filled the cavity. In its original position it had involved the ethmoid, and was pushing its way into the nasal cavity. A free communication between the orbit and the nose followed the operation. The patient had no symptoms of meningitis afterward. It is doubtful, in Dr. Lewis' opinion, whether the paralysis of the left hand was from meningeal or cerebral trouble. Although the temperature rose to 106.3° F. on the second day, no antipyretic medicines were employed, other than sponging with alcohol, hot applications to the eyelids, and morphine to relieve the pain. The nutrition was carefully attended to. In all this, Dr. Lewis's treatment, as has been indicated by me in discussing erysipelas, has my most cordial indorsement. I am very much opposed to the use of antipyretics, except in malaria or kindred diseases. The atrophy of the optic nerve, which followed the operation, was no doubt due to the traumatism, but as optic neuritis had begun prior to the operation, it certainly would have occurred later.

EXOPHTHALMIC GOITRE.

Basedow's or Graves' Disease.—This form of disease, sometimes called for those authors, Basedow or Graves, who wrote upon it at an early date, as its names indicate, is associated with enlargement of the thyroid body. It is usually also connected with cardial disturbance, either organic or functional. This is shown by frequency of the pulse, and general nervous excitement. The disease may be caused by fright, nervous shock, and so forth. For example, in some cases that I have seen, the exophthalmos and goitre are first observed after the fright of escape from a burning house—sudden and profound grief from the sudden death of relatives or friends—long-continued anxiety. It is, therefore, primarily a disease of the nervous system and should be classified as such, and not among ophthalmic diseases, the exophthalmos being the only symptom that refers the disease to the eye. The disease in rare cases runs such a violent course, as to cause such a protrusion of the eyeballs that the eyelids cannot cover them, and ulceration of

the cornea occurs. Prolonged closure of the eyes may alleviate this condition, and sometimes induce the cornea to heal.

DISEASES OF THE BRAIN AND OPTIC NERVE.[1]

HEMIOPIA.

Hemiopia, hemianopsia, or hemianopia (ἡμι, half, ὄψις, sight). —Hemiopia or half-sightedness, is a symptom pertaining to many varied diseases and disorders of the optic nerves, either in their course or at their origin, and while it is only a symptom, it deserves especial mention, although a full discussion of the conditions causing it would be only in place in a treatise on diseases of the brain and nervous system. It sometimes occurs as a functional disease, that is to say, it appears and disappears without any trace of its having existed. This may occur in sick headache, *migraine*, and in conditions known as lithæmic or gouty.[2] Occurring in this manner, hemiopia is generally overlooked, for the patients complain usually of a great loss of vision, and do not always definitely describe the hemiopia which may occur. Its principal importance, however, as a symptom, is when it is caused by tumors of the nerve or brain, inflammations, softenings, or hemorrhages. We may have lateral hemiopia, in which a vertical half of the visual field is cut off. Lateral hemiopia may be homonymous, that is to say, there is half-blindness on the corresponding sides of each eye, for example, on the left in one, and the right in the other. In temporal hemiopia the outer half of each eye is involved, and in nasal the inner halves. Writers also speak of a cutting off of the upper or lower segments, or even of the irregular portions of the visual field as hemiopia. These are hardly to be considered as typical cases, but they belong, as a rule, to limitations of the visual field such as have been discussed in atrophy of the optic nerve and glaucoma. In speaking of hemiopia, the regular vertical cutting off of the field, is usually meant. The varied

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[1] This section is unavoidably misplaced. It should properly come in Diseases of the Optic Nerve.

[2] Dana: "Text-Book of Nervous Diseases," New York, 1892.

situations of hemiopia, depend on the disease which affects the fibres of the optic nerve in their course from the eye to the visual centre, which is situated in the occipital vertex. Each occipital lobe is supplied by nerve-fibres from one-half of the retina of each eye. This can be understood by examination of Figure 30, illustrating the anatomy of the origin and course of the optic nerve, on page 91. In nasal hemiopia, the lesion is situated in front of the chiasm. In temporal, it is just back of the chiasm. In lateral hemiopia, the lesion lies farther back than the chiasm, in the optic tract, the primary centres, the optic radiations, or in the occipital lobes themselves. In hemiopia from disease of the nerve as far back as the primary centres in the optic thalamus and corpora quadrigemina, when a ray of light is thrown upon the blind side of the retina, there is no light-reflex,[1] but the pupil still contracts when the light is thrown on the sensitive side of the retina. This phenomenon is called "Wernicke's hemiopia pupillary reaction." If in hemiopia the light-reflex remains, the lesion is back of the primary centres, and involves the optic radiations or the cortex.

To test the condition of hemiopia in its early stages, and in stupid or partially comatose patients, it is recommended to bring the finger suddenly in front of the eye on the sound side, when a wink will occur. If brought in front from the blind side, the orbicularis does not contract.

It is generally considered that hemiopia is a sign of organic disease, with the exceptions that have been noted of its occurrence in migraine and similar affections. It is said not to occur in hysteria. Hemiopia, if it exists, can be readily detected with the perimeter.

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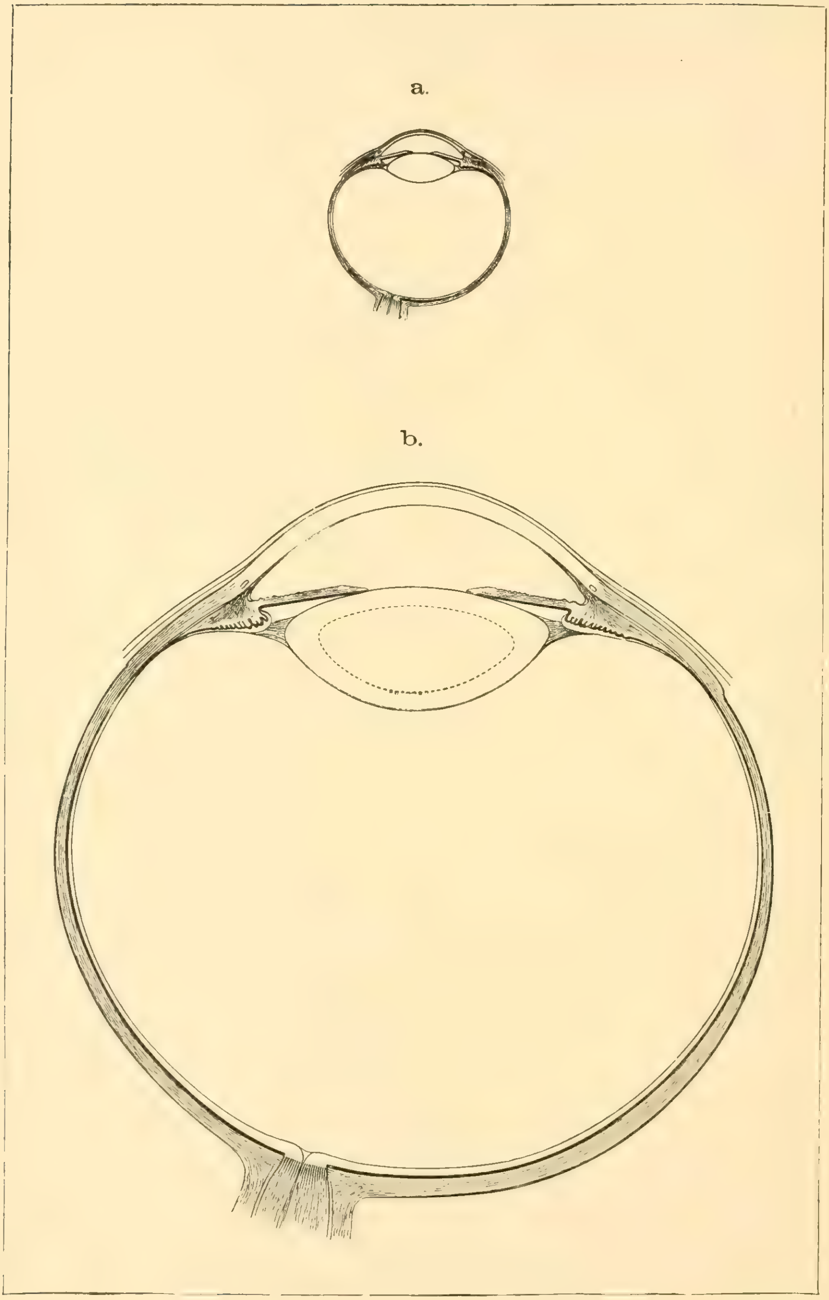
[1] Dana, *loc. cit.*, p. 113.

PART IV.

CONDITIONS OF THE EYE REQUIRING THE USE OF GLASSES—ERRORS OF REFRACTION AND ACCOMMODATION—STRABISMUS. AFFECTIONS OF THE OCULAR MUSCLES.



HORIZONTAL SECTION OF THE HUMAN EYE.

a, NATURAL SIZE. *b*, MAGNIFIED FOUR TIMES (LINEAR ENLARGEMENT).

After Elfinger—Archiv für Ophthalmologie, III., Bd. 2d.

CHAPTER XXVI.

CONDITIONS OF THE EYE REQUIRING THE USE OF GLASSES.

History of the Use of Glasses.—Increased Demands upon Eyes.—The Premature Use of Glasses.—The Influence of Electric Light on the Eye.—Table Showing Asthenopic and Non-Asthenopic Occupations.

GENERAL OBSERVATIONS.

It is now only about fifty years, since glasses were accurately fitted to the different conditions of the eye, requiring their aid. The oculists of the olden time, after having removed a cataract, sent the patient to a watch-maker, who sold him the best convex glasses that he and the patient could choose. In the same manner glasses for near-sightedness, and the so-called *far sight* of old age, were adjusted without regard to scientific and accurate rules, for there were no such rules. But there was no exact knowledge even of the conditions of aphakia, myopia, and presbyopia, while the very existence of hypermetropia and astigmatism was generally unknown, until Donders, on the slight foundation of the single observations of Thomas Young and Airy, by great labor and by the accumulation of the products of a vast experience, built a solid and enduring structure. These labors of Donders have formed the groundwork of professional observation ever since. They were epoch-making discoveries, on which all correct practice has been based for the last three decades of time. It is no qualification of these statements to say, as Donders very generously does in the preface to his work, that the English writers, "Young, Wells, Ware, Brewster and Airy had pointed out the track that he only had to follow," for although this preliminary work was fundamental and essential, it was reserved for Donders, to dig it out from generally inaccessible mines, to smelt it, and in his mint transform it into coin of the realm. Before his discoveries, and his

classification and arrangement of what was already known, those interested in the scientific study and practice of ophthalmology, were groping about in the dark, and consequently making many errors.

Donders struck the key-note when he claimed to find in fixed conditions, chiefly in hypermetropia, the usual cause of inability to continue to use eyes not affected with organic disease. His investigations were made at a time when the professional mind was bent upon finding in changeable conditions, that is to say, the action of the external ocular muscles, the causes of asthenopia and even of myopia. But when the ophthalmoscope was invented by Helmholtz, and we were enabled to measure the refraction of the eye, and when the same great genius added to the ophthalmoscope, the ophthalmometer, and exact measurements of the cornea, revealed the nature and usual situation of astigmatism, all these errors were swept away. Insufficiency of the internal recti muscles, which Graefe was then investigating, was all that was left of even assumed importance, in the estimation of the proper glasses to be used by those requiring their aid. As we shall see, there has been in later years, a revival of the doctrine of the independent influence of the external muscles in producing asthenopia. But in my opinion, this revival was based upon faulty observations, and a disregard of a proper definition of what constitutes true asthenopia, that is to say, the line was not clearly drawn between pain in the eyes, produced by organic disease, such as hyperæmia of the optic nerve and retina, choroidal irritation, inflammation, incipient cataract, and so forth, and that which is due to improper optical conditions. But this subject will be more fully discussed, in the consideration of the series of symptoms comprehended under the term asthenopia. I aim to give the student and practitioner, a clear idea of just what are these fixed conditions of the eyeball, which require the use of glasses. I think it will be seen that considerable advances of great service have been made in our knowledge, in practice, since Donders' time, but chiefly, and perhaps entirely, on lines laid out by him. Wherever there has been great deviation from these paths, error has been fallen into. Just as he followed Young and Brewster, modern ophthalmology should follow Donders, for the principles that he established

are unalterable. All the mistakes of our time, have been made by attempting to build on other foundations.

The demands upon eyes in our days have greatly increased over those made by our ancestors. There are many more books, magazines, and newspapers to read. Mechanical employments upon fine objects have become more common in this country, as our population has grown denser. Besides all this, the publishers and printers of the world, have everywhere availed themselves of the fact that glasses assist very much in vision, and have taken liberties with the public in the way of printing in fine types and in the use of old plates, which give indistinct impressions on the retina and make great demand upon eyes. This latter state of things is one that every physician should combat. Books should always be well printed, type should always be clear, no matter if by dint of spectacles much can be read that our ancestors, with their poor knowledge of the resources in glass lenses, would never have attempted. Then again, the demands upon school children's eyes, have been excessively increased, in the United States at least, in the last fifty years. Children in public schools who will never be able to spend but a few years in study, are compelled to take up an inordinate number of varied pursuits, and to spend altogether too many hours over books. The practice of writing exercises has been largely multiplied in some of the public schools, in New York City, and in the cities of this State. These so-called advances in the methods of teaching, involve excessive use of the eyes under sometimes very unfavorable conditions, that is to say, over desks of inappropriate height for the scholars, in rooms poorly lighted, with air that is sometimes foul for hours. Children are given too many studies to work out at home. It is idle to think that any science can combat such conditions as these. The conditions themselves must be changed, or we shall find a race of myopes and asthenopes, growing up where formerly we had strong-eyed people. This is an evil that is beginning to be appreciated in some of the private schools. But some of the teachers in the land, seem to be the natural enemies, not of the doctor, as one of them once suggested, but of the laws of hygiene, which the doctor endeavors to enforce.

In what is said in these chapters on the matter of relieving

weak sight with glasses, let it be fully understood that I never, for an instant, condone bad habits which often force glasses upon young people prematurely, and which cause evils that they can only imperfectly remedy. There is many a hyperopic or astigmatic person who would never use glasses until presbyopia came on if the eyes were used under favorable conditions. If one were to put down on paper, the number of hours that young children attending many schools are compelled to use their eyes on close objects, the table would appear like an exaggeration. I plead earnestly, therefore, that physicians will constantly bear in mind the fact that eyes, especially the eyes of young people, like brains and the muscles of the human body, may be overtaxed.

THE INFLUENCE OF VARIOUS KINDS OF LIGHT ON THE EYE.

The change in our methods of lighting habitations and places of business has, in some respects, been beneficial, and in others harmful. It is certainly an advantage to have a bright light, if steady and well shaded. A white light is also the one that nearest approaches daylight, and, therefore, the best; but the modern electric light is sometimes unsteady, and is often improperly protected from striking the eyes of the worker. It is a great advance from the tallow dip of our ancestors, to kerosene, gas-light, and electric illumination, but if these better lights are not used with safeguards and care, like all modern inventions, they may become sources of evil.

Dr. Andrews,[1] in the course of an interesting article on the electric light as an illuminator, concludes that the incandescent light, because of its steadiness, adequate power, and composition, occupies at the present time the first position as a means of artificial illumination. Dr. Agnew indorsed this view in the discussion which followed, and I am also of the opinion that it is the best artificial light for ordinary purposes, although asthenopia has been observed, that was thought to be due to work by electric light.[2] To work both night and day by artificial light, no matter what the source of illumination, is no doubt harmful,

[1] Transactions of the American Ophthalmological Society, 1885, p. 228.
[2] C. S. Bull, Discussion at Academy of Medicine, 1893.

but if one is obliged to, an electric light is much to be preferred to gas or to a lamp.

OCCUPATIONS OF THOSE SEEKING THE AID OF GLASSES.

I have caused the following table to be made, showing the occupations of the last thousand patients, who came to my clinic at the Manhattan Eye and Ear Hospital, on account of conditions of the eyes which required the use of glasses. The occupations which may be said to be those inducing fatigue of the eyes are classified by themselves, as asthenopic occupations.

ASTHENOPIC OCCUPATIONS.

Actors	2	Myopia.
Agents	6	Hyperopia, 3; hyperopic astigmatism, 3.
Architect	1	Compound hyperopic astigmatism.
Artists	13	Hyperopia, 11; myopia, 2.
Awning-maker	1	Hyperopia.
Book-folders	7	Hyperopia, 3; Hyperopic astigmatism, 3; myopia, 1.
Book-keepers	9	Hyperopia, 5; myopia, 3; myopic astig. 1.
Book-sewers	2	Hyperopia, 1; myopia, 1.
Card-cutter	1	Hyperopic astigmatism.
Card-maker	1	Hyperopia.
Carpet-layers	22	Hyperopia, 11; hyperopic astigmatism, 11.
Chemist	1	Hyperopic astigmatism.
Cigar-makers	14	Hyperopia, 3; hyperopic astigmatism, 7; myopia, 1; myopic astigmatism, 3.
Clerks	82	Hyperopia, 41; Hyperopic astigmatism, 30; Myopia, 9; myopic astigmatism, 2.
Clothes examiner	1	Myopia.
Draftsman	1	Hyperopia.
Electrotyper	1	Hyperopia.
Engineer	9	Hyperopia, 4; hyperopic astigmatism, 5.
Engraver	1	Hyperopia.
Feather-cutter	1	Myopic astigmatism.
Glaziers	13	Hyperopia, 2; hyperopic astigmatism, 11.
Hair-dressers	2	Hyperopic astigmatism.
Hatters and Hat-makers	6	Hyperopia, 3; hyperopic astigmatism, 3.
Kid-glove makers	2	Hyperopia, 2.
Knitters	4	Hyperopia, 2; myopic astigmatism, 2.
Letter-carriers	3	Hyperopia, 1; hyperopic astigmatism, 2.
Machinists	11	Hyperopia, 4; hyperopic astigmatism, 5; myopia, 1; myopic astigmatism, 1
Milliner	1	Hyperopia.
Ministers	11	Hyperopic astigmatism.

Painters	13	Hyperopia, 1; hyperopic astigmatism, 5; mixed astigmatism, 2; myopia, 5.
Paper-hangers	3	Hyperopia, 2; myopia, 1.
Photographers	4	Hyperopia, 3; myopia, 1.
Printers	8	Hyperopia, 2; hyper. astig., 4; myopia, 2.
Reporter	1	Hyperopic astigmatism.
Salesmen	2	Myopia.
Sewing-women	141	Hyperopia, 66; hyperopic astigmatism, 42; mixed astigmatism, 3; myopia, 26; myopic astigmatism, 24.
Shoemakers	22	Hyperopia, 8; hyperopic astigmatism, 8; mixed astigmatism, 2; myopia, 4.
Silk factory	1	Myopia.
Stenographers	7	Hyperopia, 5; hyperopic astigmatism, 2.
Students	5	Hyperopia, 2; hyperopic astigmatism, 3.
Tailors	29	Hyperopia, 8; hyperopic astigmatism, 11; mixed astigmatism, 2; myopia, 8.
Teachers	8	Complex hyperopic astigmatism, 3; hyperopia, 1; myopia, 3; myopic astigmatism, 1.
Thread-mill operator	1	Hyperopic astigmatism.
Upholsterers	4	Myopia.
Weavers	8	Hyperopia, 4; hyperopic astigmatism, 4.
	486	

NON-ASTHENOPIC OCCUPATIONS.

Bakers	2	Hyperopia, 1; myopia, 1.
Barbers	2	Hyperopia.
Bartenders	9	Hyperopia.
Blacksmiths	2	Hyperopia.
Boatman	1	Hyperopia.
Bonnet-frame makers	2	Hyperopic astigmatism.
Bootblack	1	Hyperopic astigmatism.
Bottle-washer	1	Hyperopia.
Box-makers	2	Hyperopic astigmatism.
Brass finishers	12	Hyperopia, 1; myopic astigmatism, 11.
Brewer	1	Hyperopia.
Bricklayers	3	Hyperopia, 1; hyperopic astigmatism, 2.
Butchers	4	Hyperopia, 1; hyperopic astig., 1; myopia, 2.
Butler	1	Hyperopia.
Carpenters	28	Hyperopia, 14; hyperopic astig., 9; myopia, 5.
Clay-pipe maker	1	Hyperopic astigmatism.
Coachmen	7	Hyperopia, 2; hyperopic astigmatism, 5.
Collector	1	Myopia.
Conductor	1	Hyperopia.
Cooks	22	Hyperopia, 8; hyperopic astigmatism, 12; myopic astigmatism, 2.
Coopers	2	Hyperopia, 1; hyperopic astigmatism, 1.
Cup-makers	2	Hyperopia, 1; myopic astigmatism, 1.
Cutter	1	Hyperopia.

Domestics	102	Hyperopia, 52; hyperopic astigmatism, 31; myopia, 8; myopic astigmatism, 11.
Drivers	32	Hyper., 15; hyperopic astig., 14; myopia, 3.
Dyer	1	Hyperopic astigmatism.
Electric light	2	Hyperopia.
Errand	1	Myopia.
Farmers	3	Hyperopia, 3.
Fireman	1	Hyperopia.
Freight Inspector	1	Hyperopia.
Gardeners	3	Hyperopia, 1; hyperopic astigmatism, 2.
Gateman	1	Hyperopia.
Gilder	1	Myopic astigmatism.
Grooms	12	Hyperopia, 1; hyperopic astigmatism, 11.
Janitor	1	Hyperopic astigmatism.
Jeweller	1	Hyperopia.
Keeper, Sing Sing	1	Myopia.
Laborers	144	Hyperopia, 76; hyper. astig., 51; myopia, 17.
Marble-cutter	1	Hyperopia.
Matrons	3	Hyperopia; 1 hyperopic atigmatism, 2.
Messenger	1	Hyperopia.
Missionaries	2	Hyperopia, 1; hyperopic astigmatism, 1.
Moulders	4	Hyperopia, 2; mixed astig., 1; myop. astig., 1.
No occupation	24	Hyperopia, 11; hyper. astig., 10; myopia, 3.
Nurses	22	Hyperopia, 10; hyperopic astigmatism, 11; mixed astigmatism, 1.
Packers	2	Hyperopia, 1; myopia, 1.
Peddlers	13	Comp. myopic astigmatism, 11; myopia, 2.
Plasterer	1	Hyperopia.
Plumbers	13	Hyperopia, 1; hyperopic astig., 11; myopia, 1.
Policemen	12	Hyperopia, 1; hyperopic astigmatism, 11.
Porters	29	Hyperopia, 10; hyperopic astigmatism, 5; mixed astigmatism, 11; myopia, 1; myopic astigmatism, 2.
Quarryman	1	Myopia.
Roofing	2	Hyperopia.
Sailors	10	Hyperopia, 6; hyperopic astigmatism, 4.
Soldiers' Home	1	Hyperopic astigmatism.
Stablemen	2	Hyperopia, 1; hyperopic astigmatism, 1.
Steam-fitters	2	Myopia, 1; myopic astigmatism, 1.
Stone-cutters	5	Compound hyperopic astigmatism 5.
Switchmen	2	Hyperopia, 1; hyperopic astigmatism, 1.
Telephone operator	1	Hyperopic astigmatism.
Tinsmith	1	Hyperopic astigmatism.
Varnish-maker	1	Mixed astigmatism.
Waiters	14	Hyperopia, 11; hpyeropic astigmatism, 3.
Waitresses	5	Hyperopia, 1; mixed astig., 1; myopia, 3.
Washing	27	Hyperopia, 13; hyper. astig., 9; myopia, 5.
Watchmen	18	Hyperopia, 7; hyper. astig., 10; myopia, 1.
Wood-polisher	1	Hyperopia.
	645	

As far as a table like this can exhibit any facts, it seems to show that people occupying themselves excessively with the use of their eyes on fine objects, do not require aid with glasses in greater proportion than those pursuing what might be termed non-asthenopic occupations. Indeed glasses are asked for as a necessity for the ordinary work or occupations of life. To this an exception must be made in the exhibit of the number of sewing-women, 141, a large proportion of the whole number. There were also 102 domestics or female house-servants. Undoubtedly a goodly number of these used their eyes very much in sewing, although I have not felt justified in classifying domestic service as an asthenopic occupation. A table of this kind made up from private practice, would of course show a larger proportion of people using their eyes in occupations demanding close and exact use of the eyes. Until the widespread knowledge of the existence of hypermetropia and hypermetropic astigmatism, and of the benefits from the use of spherical and cylindrical glasses, most of these patients would have found no relief from a visit to an ophthalmic clinic. The table at least exhibits the advance made in ophthalmology since 1854, when Donders' treatise was published in the English language.

CHAPTER XXVII.

HYPERMETROPIA.

Discovery by Donders.—Definition.—Professor Dewey's discovery.—The Connection between Hypermetropia and Asthenopia.—Asthenopia caused by an Error of Refraction.—True and False Asthenopia.—Muscular Asthenopia.—Donders' Description of Asthenopia Caused by Hypermetropia.—Symptoms produced by the Use of the Eyes under Improper Conditions.—American Asthenopia.—Tenotomies of the External Muscles.—Neurotic Asthenopia.—Nasal Asthenopia.—Dr. Gruening's Observations.—Dr. Pooley.—Accommodative Fatigue a Cause of Asthenopia.—The Two Kinds of Asthenopia recognized by Drs. Derby and Dyer.—The Emmetropic Eye.—The Different Forms of Hypermetropia.—Mydriatics in Making the Diagnosis.—Axial Refraction.—Testing Vision for Glasses.—Rules for Prescribing Glasses.—Acquired Hypermetropia.—Absolute Hypermetropia.—The Importance of Heredity.—Professor Hansen-Grut.—Asthenopia even when Attended with Hypermetropia not Always Corrected by Convex Glasses.—Spasm of Accommodation.—Definition.—Calabar Bean.

DONDERS' great discovery was that of the widespread existence of *Hypermetropia* (ὑπερ, beyond; μετρον, measure; ὤψ, the eye). This is the state of the eye when it is too short from before backward. When the eye is at rest, parallel rays are focused behind the retina (Fig. 163). Convergent rays which do not exist in nature are united in such eyes upon the retina.

This condition, when of a high degree, was known to exist here and there in the civilized world, as shown by the fact that young persons occasionally wore convex glasses, although usually advised by such expert writers on ophthalmology as Mackenzie, of Glasgow, not to do so. Our countryman, the late Professor Dewey, of Union College,[1] wrote a paper describing the condition, or its symptoms, but it may be said to have been discovered by Donders.

The exact language of Professor Dewey is as follows:

"ON AN UNNOTICED KIND OF ABNORMAL VISION.—There are two well-known kinds of *abnormal* vision in eyes not diseased, the

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[1] American Journal of Science and Arts, vol. viii., November, 1849, p. 443.

far-sighted and the *near-sighted.* The former occurs in good eyes, in persons advanced in life, beginning about the age of forty, and is remedied by *plane*, or better by *convex*, spectacles. The latter is found in youth or young persons, and finds its remedy in concave glasses. . . . There is a kind of abnormal vision, different from either of these, which is not far-sighted nor near-sighted, but in which near small objects, or larger distant objects, are not seen with distinctness. This imperfection occurs in children and young persons, and is remedied by convex spectacles which are suited to the eyes of persons from sixty-five to seventy years of age. The younger eyes require the older glasses, and with advancing years less convex glasses are required. At the age of forty-five or more, this kind of abnormal vision becomes much diminished. As the young use the glasses of the far-sighted, this kind may be called *neo-macropia.* It is evident that convex glasses produce that change in the rays of light which fits such eyes to see distinctly small and large objects at varying distances. This fact proves that there is no defect in the adjusting power of the eyes. The cause, then, is to be sought in the structure of the eye."

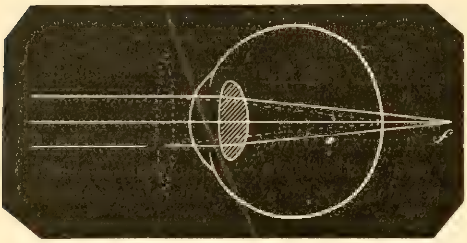

FIG. 163.—PARALLEL RAYS FOCUSING BEHIND THE RETINA.

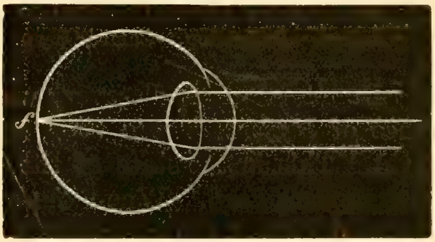

FIG. 164.—PARALLEL RAYS FOCUSING EXACTLY ON THE RETINA.

Professor Dewey goes on to say that these causes may be as follows:

"First, too little convexity of the crystalline lens; second, its position too near the retina; or, third, its too little density. The second is the probable cause. Spectacles sufficiently convex would bring the rays to a focus, let either or all of the three causes operate, and with the usual adjusting power of the eye, give distinct vision for near or remoter objects. Though this kind of abnormal vision seems not to have attracted attention, for I have found but one allusion to it in consult-

ing authorities on optics, it is relatively common. In New England and New York more than fifty instances of it have come to my knowledge in the five or six years past. A child of fifteen was able to see distinctly, for the first time, by the use of his grandfather's spectacles. A young man of eighteen required convex glasses of ten inches focus, while persons of seventy years use those of fourteen to eighteen inches focus. Children often make little progress in study because they do not see objects distinctly, though the defect is not

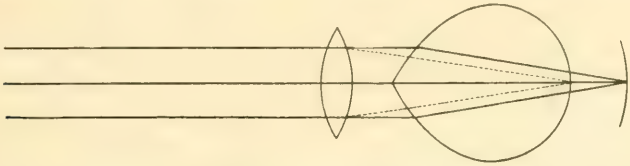

FIG. 165.—SHOWING THE ACTION OF A CONVEX LENS PLACED IN FRONT OF AN EYE THAT IS TOO SHORT. The dotted lines show the increased convergence caused by the lens.

suspected by them, and is utterly unknown to parents and teachers. A knowledge of this subject will make spectacles a still greater benefit to our race."

Professor Dewey continued this subject in 1856,[1] by saying that he has found many other cases. He remarks that Dr. DeForest, of the Syrian Mission, described to him a marked instance of it in a girl belonging to the mission at Beirut. He says there is a striking instance in his city (Schenectady) now before him, a boy near fourteen years of age:

"He never saw objects distinctly until he happened to put on the spectacles used by his grandfather. He now uses constantly the convex glasses suited to ordinary eyes of persons eighty years of age. Indeed the focus is much too short for my old eyes, as his glasses have the principal focus less than six inches, while mine is fourteen inches. Without glasses he can see very little, and with them at all distances distinctly."

While Professor Dewey had many incorrect ideas in regard to this condition, he was right in so many, that, had he published his observations in a medical journal, with his urgent advice that convex glasses be given to such children instead of denying them to them, as eminent authorities then advised we should be able to give him the honor of having discovered the

[1] American Journal of Science and Arts, vol. xxii., November, 1856, p. 301.

condition which he called *neo-macropia*, but which is better known as *hypermetropia*. This discovery of hypermetropia was made possible only by the ophthalmoscope, although its existence could have been inferred, as it was by Dewey, by the familiar fact to which I have alluded, that the eyes of certain young persons were benefited, that is, the vision was improved, by the use of convex glasses, when the lens was proven to be present. Yet to all essential purposes, it was Donders who first demonstrated the frequent existence of an eyeball too short from before backward, an eye of low refractive power, which was greatly assisted in its work by the use of convex glasses.

In hypermetropia he found the chief cause of asthenopia. Indeed his statement is so broad, that it is evident that he considered true asthenopia as always caused by hypermetropia. His exact words are:[1] "I have already asserted that hypermetropia is usually at the bottom of asthenopia. The truth of this assertion has been doubted. I now, however, go a step further, and venture to maintain, that in the pure form of asthenopia, hypermetropia is scarcely ever wanting." The investigations of the last thirty-five years have not overthrown the fundamental truth of this statement. But increased knowledge has forced us to give hyperopic astigmatism, a more prominent place in the production of asthenopia, than was formerly assigned to it.

ASTHENOPIA.

It will be more convenient to discuss the general subject of asthenopia under the heading of hypermetropia than at any other point, since we have such high authority for considering a hypermetropic formation of the eyeball to be at the foundation of most cases of true asthenopia. As I fully adopt this opinion, having amplified it in the manner indicated by including hyperopic astigmatism, I wish to set forth plainly what I consider to be erroneously called asthenopia, as well as the real symptoms.

Asthenopia may be divided into true or local, and the false or symptomatic. I regard true asthenopia as that which depends upon a refractive anomaly, and I consider that as symp-

[1] "Anomalies of the Refraction and Accommodation of the Eye," p. 261.

tomatic or false, which depends on some error in the general nutrition, neurotic constitution, nervous exhaustion, or the like. These have been very much confounded in the discussions which have obtained in this country on this subject, but I hope to make the whole matter so clear, that the student will have no difficulty in recognizing the two forms.

It is my conviction that the time has come, when the whole subject of asthenopia may be rewritten in the light of recent investigations. My readers need not be reminded, that the scientific consideration of this subject, is entirely a matter of the last thirty to thirty-two years. It was not until then, that glasses were adjusted on scientific principles. These principles were laid down by Donders, first by communications in the Dutch language in medical articles, which of course had a very limited circulation, and then in his monograph on astigmatism and cylindrical glasses. Finally in 1861 or 1862, the whole English-speaking profession was reached by his famous work, on the "Anomalies of Refraction and Accommodation of the Eye."

Whatever follows in the chapters which I now present, is built on the broad and solid foundation, which the eminent Dutch physiologist then laid down. But it was only a foundation. No complete superstructure could be erected until the materials had been gathered from far and near. The time, however, for this, it seems to me, has come. This whole subject has been investigated in various directions, by many observers, some of them of the highest order, and a vast quantity of material has been collected, which has not yet been used in any complete treatise of which I have any knowledge. What is much worse, there has been a great deal written, avowedly not on the basis of Donders' investigations, but claiming to involve new ideas on this subject, which seems to me, in many instances, to be but a going back to the erroneous doctrines which Donders undertook to combat.

I shall attempt to define the condition known as asthenopia, on a somewhat broader basis than that adopted by Donders, but yet essentially the same. Asthenopia means an inability to continue to use the eyes on near objects, without involving painful consequences. Some of these consequences are at once appreciable, and cause the patient to stop his occupation, indeed compel

him to. Such are, pain in the eyeballs, watering of the eyes, feeling as if sticks were in them, a band running about the eye, and so forth. But there is another set of symptoms, which do not compel the patient to stop work, and for which he does not always seek relief. Inflammation of the edges of the eyelids, peculiar headaches, and conditions resulting from asthenopia, which have not been until lately generally recognized in the profession, also depend upon it. This neglect to seek relief at the hands of surgeons is due to the old tradition, that nothing can be done for such a state of things. Of late years, too much stress has been laid upon the condition of the eyes in producing constitutional symptoms. Certain constitutional conditions that involve accommodative fatigue, or fatigue of the ciliary muscles, may produce symptoms simulating true asthenopia, but these should be carefully distinguished from those resulting from errors of refraction. Epilepsy, chorea, and so forth, have been thought to result from these conditions. With that doctrine, after patient and careful investigation, I have no sympathy. I shall teach that there are no reflex symptoms from the eyes, unless the eyes themselves give warning that they are not doing their work properly. Latent errors of refraction have very little to do as a rule, in my opinion, even in the causation of asthenopia, and nothing whatever in the production of constitutional disease.

MUSCULAR ASTHENOPIA.

Although I formerly accepted the ordinary classification of an asthenopia dependent upon insufficiency of the external ocular muscles, I have come finally to reject it altogether. Of course, I do not deny the existence of insufficiencies of the interni, chiefly in myopia, and of the externi, principally in hypermetropia, nor do I deny that there are many eyes whose external muscles are not capable of doing the average degree of work, but I hold that all these conditions depend on static, fixed conditions of the eyeball; that they are direct consequences of these conditions and should not be denied a special nomenclature, but should be classed under the heading of asthenopia occurring in myopia, hypermetropia, hypermetropic astigmatism, and so forth, from faulty conforma-

tion of the eye. I formerly measured the relative power of muscles, but, as has been shown in another part of this book, this relative power varies in different individuals, who have no trouble with their eyes, and I therefore no longer measure it, any more than does the surgeon the relative contractile power of the fingers, legs, or arms. Physiologically, it may be interesting, but it can do nothing toward a proper treatment.

It is well known to the profession, that in 1841–42 Bonnet and Petrequin, supposed that they had found the primary cause of asthenopia in the muscles of the eye, but especially in the external muscles. Mackenzie shared their view, and endeavored to show that asthenopia was not entirely due to a fault in the accommodative muscle.[1] While Donders removed a very large class of cases from the category of muscular asthenopia by his discovery of hypermetropia, he still, owing, as I think, to his reverence for the opinions of Graefe, admits a separate discussion of asthenopia, due to the insufficiency of the internal recti. It was from Graefe's work that muscular asthenopia held its position for a long time, and does still in very large circles, and was and is treated by prisms and tenotomies. In America, especially, many of the profession, ascribe not only asthenopia, but also grave constitutional affections, to weakness of the muscles of the eyeball.

It was chiefly in Paris by Javal, and his limited following, prominent among whom was Dr. G. J. Bull, that astigmatism was brought forward as making, with hypermetropia, the principal factor in the causation of asthenopia. My chief reason for the giving up of the treatment of muscular asthenopia, as such, was first suggested to me by the fact, that in a large number of cases correction of astigmatism entirely removed the necessity for prisms, and the troublesome symptoms that were ascribed to be dependent upon muscular insufficiencies, and with more thorough examination for astigmatism, the number of these cases increased. The perfection of the ophthalmometer in 1888 soon made me abandon all other means of determining the existence of astigmatism, and, as indicated, for this I undertook a series of examinations of the ocular muscles in persons clearly not asthenopic, nor suffering from nervous disease, with the results above

[1] Ophthalmic Review, October, 1890.

stated. I believe that if we set aside sentiment as to Graefe's discoveries and preconceptions, and examine asthenopia in the light of Donders' work upon hypermetropia, and that of Javal upon astigmatism, we shall have no occasion to look to insufficiencies as faults needing correction, except when they cause deformity or destroy binocular vision, when, if possible, they are to be removed by operations. The sources of true asthenopia and its results are, in my judgment, to be found in ametropia.

The following case illustrates very well the class of cases for which divisions of the muscles are performed, and which were formerly classified under the head of "muscular asthenopia:"

I saw the case first in 1880, some seven years before my thorough knowledge of the importance of correcting astigmatism before taking any account of muscular defects.

The subject, Mr. H. A. X., is a clergyman, 30 years of age when I first saw him, now 43, who is of a neurotic disposition and temperament, and of neurotic ancestry. I knew his father and other members of the family, and will describe him as a gentleman who laid great stress on very small matters,—was painfully exact, painfully sensitive. This is a type of case that one often sees, and they become ready victims to any prolonged system of medication, by which great hopes of cure, of what is incurable, are held out. His history was, when he first consulted me, that he had observed double vision when looking through an opera-glass, and at other times, some fatigue in reading; objects ran together. He was in good health. Distant objects were sometimes blurred. His vision was $\frac{20}{20}$ on each side. He would accept no glasses. His near point was six inches. His interni overcame prisms of 10°, the externi 12°. The refraction of his eyeball was hyperopic. No astigmatism was discovered, and he was given a weak convex glass. He had had double vision at times from his youth, suffered from headaches, dyspepsia, pain in the back. He had migraine. I saw him again one year afterward, when he had more symptoms, tired feelings in his eyes, even when not working. In looking to the right objects were spread and blurred, either with or without glasses. No distinct double vision now. Finds comfort in his weak, convex glass. He had a painful upper molar tooth, the extraction of which was advised. His interni then could overcome a prism of 18°, externi one of 12°. Movements were normal. He was not seen again for three years, when he had pain in his eye, some photophobia, considerable headache, which comes

and goes. Thinks the glasses make his eyes itch. Vision as before. Conjunctiva injected. He then left me, and did not appear again for six years, when he had had his muscles operated upon,—his externi divided, I think. He was still not comfortable, although he managed to keep on in his profession, and do his work with more or less thoroughness. In 1891 I examined him with the ophthalmometer, and found he had a diopter of corneal asthenopia and prescribed a glass of one-half a diopter to each eye. He finds his glasses pretty comfortable—thinks he is better than he ever has been. In 1893 he is using his eyes more and more. Without his glasses would see double. His near point is still at seven inches, with or without his cylinders. He was advised to use them for reading.

A man having this condition of refraction, of vigorous physique, not accustomed to worry about trifles, would never have had any trouble until he became presbyopic. I only quote his case to give an idea of that large number of American asthenopes who suffer in this way, who usually have from one to one and one-half diopters of corneal astigmatism, with from one to three or four diopters of hypermetropia. In my opinion, the very best that can be done for them is to make rather light of their troubles, and correct the astigmatism. This accomplishes more than any other system of treatment, and if the practitioner is firm with them, and informs the patient that this is the best that can be done, they go on with their work, and do it with very little inconvenience. At any rate, the double vision will be broken up. The convex glasses will very often accomplish the same, but since I have corrected the corneal astigmatism of one diopter, in this way, I have had even more satisfaction than by the older methods, although, so long as one does not advise prisms or operations on the muscles, the patient will do fairly well by using convex glasses.

It remains a fact, however, that true asthenopia, that is, asthenopia disconnected with serious organic changes in the eyeball, or with constitutional disorders, which are generally of a neurotic character, is chiefly caused by an error of refraction, and that error is an hypermetropic conformation of the eyeball, either of the cornea or of the eyeball, or both.

Certain neurologists assume that they can diagnosticate the origin of the headache from its situation. I present herewith

an interesting diagram from the text-book of Dr. Dana.[1] I have not been able to substantiate or disprove the correctness of Dr. Dana's view as to the situation of headaches, dependent

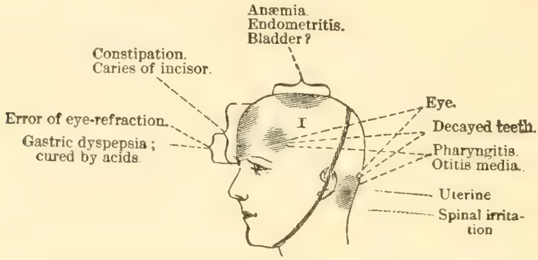

FIG. 166.—INDICATES THE SITUATION TO WHICH PAIN IS REFERRED IN HEADACHE FROM THE EYE. (DANA.)

upon uncorrected errors of refraction, but I think the diagram is an important one, and ought to be studied by those who treat diseases of the eye.

ABSENCE OF ASTHENOPIA IN MYOPES.

Myopes are rarely asthenopic. When their eyes suffer in the use of them for near objects, it is usually because the myopia is progressive, and attended by considerable congestive or inflammatory changes. This is not true asthenopia, although often confounded with it. Then again, certain invalids, neurotic invalids, suffering from neurasthenia often have great difficulty in using their eyes, but they also have difficulty in performing many functions of the body. No adaptation of glasses will materially assist such persons, except by what may be termed suggestion. Their cases should be rigorously excluded from the classification of true asthenopia. Again, women suffering from real or imaginary uterine diseases, are often unable to use their eyes at all continuously, or without inconvenience, which in many cases is greatly magnified by their own morbid sensitiveness. These persons very often show no error of refraction worthy of the name, and even if they do, the proper correction will not always give them perfect relief. Their cases also should not be classed under those of true asthenopia. Then again, after

[1] "Text-Book of Nervous Diseases," New York, 1893.

serious diseases, such as typhoid fever, *fèvre nerveuse*, or nervous fever of the French, there is generally considerable inability to use the eyes. This may last for months, but it is usually, if not always, entirely recovered from and without local treatment.

The form of asthenopia which Donders believed to be caused exclusively by hypermetropia, may be best described in his own words:

"The eye has a perfectly normal appearance, its movements are undisturbed, the convergence of the visual lines presents no difficulties, the power of vision is usually acute, and nevertheless in reading, writing, and other close work, especially by artificial light, or in a gloomy place, the objects after a short time become indistinct and confused, and a feeling of fatigue and tension comes on, in and especially above the eyes, necessitating a suspension of work. The person so affected now often involuntarily closes his eyes and rubs his hand over his forehead and eyelids. After some moments' rest, he once more sees distinctly, but the same phenomena are again developed more rapidly than before. The longer the rest has lasted, the longer can he now continue his work. Thus, after the rest of Sunday, he begins the new week with fresh ardor and fresh power, followed, however, by new disappointment. If he is not occupied with looking at near objects, the power of vision appears to be normal, and every unpleasant feeling is entirely absent. If, on the contrary, he endeavors, notwithstanding the inconvenience which arises, by powerful exertion to continue close work, the symptoms progressively increase, the tension above the eyes gives place to actual pain, sometimes even slight redness, and a flow of tears ensues. Everything is diffused before the eye, and the patient now no longer sees at first well. Even at a distance, after too long-continued tension, he is obliged to refrain for a long time from any close work. It is remarkable that pain in the eyes themselves, even after continued exertion, is a rare occurrence."

I have quoted this admirable description, which has now become classical, in full, lest the student or practitioner beginning the study of asthenopia, may confound the pure form with that which is but a symptom of general inability to properly perform any function requiring muscular exertion. Keeping this defini-

tion well in mind, it will soon be easy to find those cases of errors of refraction that actually cause asthenopia.

To Donders' definition we may perhaps add, for the sake of clearness, that these symptoms sometimes cause headaches, that may be directly traced to the use of the eyes. We may also say that local congestions, finally becoming active inflammatory processes, *blepharitis ciliaris*, *hordeola* (styes) sometimes result from the persistent use of the eyes under improper conditions. We may also admit that those thus afflicted may become melancholic, and take morbid views of life, that their digestion might become impaired, but these things that only exceptionally result from uncorrected errors of refraction, form no warrant for the extravagant claims that have been made, that epilepsy, chorea, idiocy, or even migraine, are caused by want of adjustment of the muscles of the eyes.

It is chiefly in the United States, that this extended definition of asthenopia has become current. Abroad a certain inability to use the eyes without marked symptoms, is sometimes known as American asthenopia. My own experience shows that the vast majority of patients who have consulted me have come on account of symptoms referable to their eyes only. In accordance with the theory that the causes of chorea, epilepsy, and so forth, are to be found in an error of refraction, or in the want of proper action of the external muscles, it is not necessary that the eye or its appendages should manifest any symptoms at all. They may be, it is claimed, completely concealed. Patients who never had an ocular symptom are told that all their troubles proceed from their eyes. This I do not believe is sound doctrine. A foreign body of any kind in any part of the body, if it cause reflex symptoms, will also cause symptoms at its situation. If we actually have reflex disturbances of the nervous system from the eye, the eye itself will manifest symptoms.

My reader will see from all this, that it is my belief that there will be no difficulty in tracing to the eye, in subjective symptoms, any conditions that may require surgical operations, or the use of glasses.

I frequently see young women or young men, of delicate constitution, of tuberculous ancestry, who, among other symp-

toms, finally show some ocular ones, who have been operated upon by tenotomies of their external muscles until, as their relatives and friends voluntarily state, they are completely demoralized.

Such a patient has just appeared before me: A young woman, of 23 years of age, wearing shade, glasses and prisms, having a vision of $\frac{20}{15}$ in the right eye, yet complaining that she could not bear the light, that she could do nothing at all at a near point with her eyes, although a frank letter from her physician states that he has operated upon her until he despairs of making her any better, though he has produced what he calls "parallelism of the muscles." This young woman had an astigmatism of $1\frac{1}{2}$ D. in each eye, which had been wholly overlooked, so bent were her advisers on securing the muscular balance.

With my views, such a patient should devote great care to her general health, not wear glasses, except for reading and writing, and then wear those that would correct her astigmatism. Under no circumstances should any operations have been performed. Operations here, as in hundreds of other cases, have done harm, which is possibly irreparable.

NEUROTIC ASTHENOPIA.

It will be seen that my definition of asthenopia is a very limited one, but there is an inability to use the eyes, connected with nervous disease, which I have long since called *neurotic asthenopia.* It depends on the constitutional conditions of the body, and not on the eye, although the eye suffers from the nervous deterioration. Perhaps what I mean by "neurotic asthenopia" can be better expressed by a case than any further discussion. Such patients become a prey to credulous physicians, who forget that neurotic patients give full rein to their imagination and emotions, and, like old-fashioned dyspeptics, who weigh their food, and devote their whole time to their symptoms, so the neurotic of the present day, if he receives the encouragement that he often, unfortunately, does, will, moment by moment, watch each feeling he may have in his eyes, and demand a change of glasses for every change of sensation.

While writing these words I was consulted by a merchant of 32 years of age, of New England extraction, which, by the way,

furnishes a larger contingent of neurotics than do the Middle and Southern States. About the West, I am not so well informed, but I think they share somewhat in the disposition of their New England ancestors to anxious self-introspection. This gentleman is large and well developed. He admits that he is very nervous, that he thinks much of himself. He was fitted with glasses for his ocular symptoms by a competent oculist some years ago, but from that time to this he has been consulting various authorities, and changing his glasses according to the different advice that he may receive at different times. Actually, his condition is one which usually requires no glasses at all. His vision is $\frac{20}{15}$ in each eye. He can, however, on some days wear a + 1.50 D. without any blurring of the Snellen's type. He has no corneal astigmatism. His occupation consists in selling goods by wholesale, and he occasionally travels about for that purpose, but he is obliged sometimes to look at samples during the day. He does no writing. On his first visit, he said that he did not think the glasses he was wearing were exactly right. He was wearing + 1 D. for all things, and all the time. Although his vision was perfect without glasses, he could not go about without their aid on account of nervous symptoms that appeared, did he not wear them. Then he could not look at objects a few feet from him, or farther from him than a book, without glasses. These, he thought, ought to be of a different number. Then he thought he ought to have stronger glasses for reading. Of course, this case was considered hopeless from the start. He comes under the head of a neurasthenic or a neurotic type, such as has been described in the preceding pages, and who, if he does not have a disease in his eyes, will have it in his stomach, or some other part of his body. But, as he had seen most of my brethren in the profession, I allowed him to consult me. I could make no new suggestions, except that he should attempt to go without glasses. In a few days he returned, and said that this was impossible, but instead of wearing + 1 D., that he could wear + $\frac{3}{4}$ of a diopter, and that he found this more comfortable than the 1 D. Imagine a human being, with good sight, who can tell the difference between a glass one-half a diopter and one three-quarters a diopter! Two weeks later he again returned and said he was now very comfortable for everything except for reading—that he did not find his reading glasses comfortable, and he, therefore, desired them a little weaker.

This man will go on, ringing the changes upon his glasses, until some serious trouble in some other part of his body really attacks him; then he will forget his eyes, because he has noth-

ing in them that would give him any trouble, were it not that he devotes much of his time to a consideration of his ocular symptoms. In this unprofitable use of it, he has been encouraged by a narrow specialism.

NASAL ASTHENOPIA.

Dr. Gruening[1] some years since wrote a paper upon the relief of asthenopic symptoms by treatment of the nose, and presented a large series of cases with the following features:

"1. Burning and smarting sensation of the lids of the eyes, more pronounced in the morning than in daytime.

"2. Inability to fix an object in ordinary daylight.

"3. Increased vascularity of the conjunctiva, and lachrymation upon slight provocation, such as a mild current of air.

"4. Sound condition of the eyes and their appendages.

"5. Inefficiency of the ocular and the general treatment.

"6. Efficiency of the nasal treatment in spite of the absence of nasal symptoms."

These he found were only to be cured by treatment of the nose. I have not seen any such proportion of cases as has Dr. Gruening. Convinced as I am of the great importance of treating the nose in certain affections of the conjunctiva and cornea, as I have plainly set forth in this volume, I have found but very few that answer to Dr. Gruening's account, and inasmuch as he admits that it is not possible always to tell by an examination of the nose which are the cases due to nasal troubles, I may venture to suggest that the use of the ophthalmometer would find a larger proportion of them ametropic than Dr. Gruening has, in his series of one hundred and fifty patients, and that some of them might be relieved by correction of the astigmatism. Still, it is a very important subject, and Dr. Gruening's observations are entitled to the highest consideration. The argument that he uses is, that if irritations of the Schneiderian membrane will produce grave symptoms in different parts, why should the neighboring eyes be spared?

Dr. Pooley[2] also entered upon this subject of asthenopia not

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[1] Medical Record, Jan. 30th, 1886.

[2] New York Academy of Medicine, Dec. 21st, 1893.

dependent upon errors of refraction or insufficiencies of the ocular muscles, and recognizes with myself, that it may exist quite independently of errors of refraction, but he does not lay stress upon the point which I make,—namely, that this is not true asthenopia, and may always be recognized by a careful investigation, when it will be found to be either neurotic, toxic, the fatigue of accommodation, or other conditions which may affect the muscles of the eye, in common with those of other parts of the system.

In this chapter, I discuss asthenopia from the standpoint of Donders' definition—true asthenopia, dependent on a decided error of refraction. Nowhere in medicine can more exact results be obtained, or greater benefit secured to the patient, than in this important class of cases, which Donders first elucidated. I have attempted in this rather prolix argument, to separate those worthy of the continued attention of the oculist, from those that belong to the physician or the neurologist.

ASTHENOPIA IN DISEASED EYES.

It is often forgotten that asthenopia is not only a symptom of an uncorrected error of refraction, but also, at times, of a diseased condition of the eyeball,—that is to say, asthenopia, in its broad sense, for I hold that it is usually possible, and not difficult even, to separate the asthenopia, the result of hyperopia and hyperopic astigmatism, from the pain of choroidal inflammation or irritation, or the fatigue of worn-out accommodative power, or from the difficulty in keeping the muscular balance in such a disease as locomotor ataxy. In diabetes also, one of the early symptoms (as might naturally be supposed, for this disease is apt to manifest itself in the eye), we may have inability to use the eyes in the early stages—perhaps to be continued through all the stages. In eyes predisposed to glaucoma also, and beginning to have glaucomatous symptoms, we have inability to use the eyes. Some opacities of the lens or of the capsule, are a prolific source of asthenopia. It is impossible for such patients to get very clear images on the retina, and the strain to do so produces ocular fatigue. These things have been very much overlooked in the later days, and efforts have been made to find a relief for all kinds of asthenopia by glasses,

when, as a matter of fact, relief can only be obtained, or, at least, anything like perfect relief, in those cases where asthenopia is dependent on an uncorrected error of refraction. Sometimes there is a combination of causes, for example, a young person with considerable astigmatism may first find it producing asthenopia on becoming an earnest student in school, which is not generally before the age of twelve to fifteen, or in the familiar example of the presbyope, who is not aware of his astigmatism, until the failure of the ciliary muscle compels him to seek relief for his accommodation. There is a great deal of accommodative fatigue among all classes of persons. Children recovering from the measles or other infantile diseases, in their convalescence, are very apt to amuse themselves by reading or employing their accommodation in games that require close use of their eyes, and just so, adults during convalescence, and as was observed by Dr. Gruening in a discussion before the Academy of Medicine on Dr. Pooley's paper,[1] young women confined to their rooms during the menstrual period, very often read a great deal, and fatigue their accommodation inordinately, at a time when their strength is below the average. This whole subject of accommodative fatigue in all classes of persons, has been very much overlooked, as I repeatedly intimate. The observer should carefully discriminate between a person not able to do what may be justly required of eyes, and those who overtask their eyes, especially, when their general condition does not warrant very much muscular exercise of any kind, for it is never to be forgotten that the ciliary muscle, like the muscles of the heart, is always unconsciously at work, and will wear out sooner if overtasked.

My attention was lately called at my clinic, at the Manhattan Eye and Ear Hospital, to three very striking cases, occurring in one afternoon, of young people who came for glasses, when they simply needed rest for their eyes from an undue use of the ciliary muscle. One of them was a young girl of twenty, who was teaching all day, five days in the week, in a public school, who stated that she read a great deal on Saturdays and Sundays, and that in the evening and every evening she took drawing lessons to fit herself to become a teacher in

[1] Academy of Medicine, Dec. 21st, 1893.

this department. She had no refractive error, calling for any correction, but she was simply overusing her eyes. She stated very clearly that her work during the day did not fatigue her much, but the work of the evening she found produced itching of the lids, redness of the globe, and so forth, in the morning. The two other cases were young musical students, who admitted that they took no exercise. They had begun very earnestly this autumn in their studies, which interested them very much. They worked day and night, until finally they complained that their eyes were blurring,—they could not see distinctly. These patients all might have had an error of refraction which would, of course, have aggravated their conditions. Usually a marked error of refraction is known at an early period, calls a halt in the case of those affected by it, and prevents them from using their eyes; whereas those who have no considerable error, and who have gone through all their ordinary occupations until reaching early womanhood or manhood, without over-using their eyes, are apt, if engrossing studies engage them, to overstrain their accommodation. Sometimes such straining occurs also in older persons, and if attended by weeping, and irritation of the eyes from this cause, I regard it as a serious symptom, leading us to look out for glaucoma.

In the early discussion of asthenopia,[1] the fact was recognized by Dr. Derby and by Dr. Dyer, that there were two kinds of asthenopia,—one which does not seem to depend on the refraction of the eye, and to explain which Donders gives only unsatisfactory hypotheses; the second, that which is clearly from an accommodative fatigue, induced by a marked error of refraction—hypermetropia or hypermetropic astigmatism. To this, at that time, insufficiency of the internal recti was added as a cause. Now, this form of asthenopia, in which Dr. Derby and Dr. Dyer found no refractive error, and in which there is not usually any refractive error worthy of the name, is the American asthenopia, if I may so speak, for which so much has been attempted by the correction of latent insufficiencies of the muscles, or by the use of glasses for errors of refraction, so slight that they do not detach the eyes from the category of normal ones. It is around this class of cases that so much ob-

[1] Transactions of the American Ophthalmological Society, vol. i.

security has come, in consequence of the assumption that if the proper glass were chosen, or the proper muscle divided a sufficient number of times, finally the asthenopia would be cured. It is what I have denominated as neurotic asthenopia—seldom cured, although it may exist temporarily in certain cases of constitutional disease and then be recovered from. It really is not entitled to a place in the category of ophthalmic affections.

When the general existence of hypermetropia was demonstrated, it seems to have been supposed that there was a large proportion of the human race, who not being myopic, or hypermetropic, were what Donders defines to be as emmetropic.

EMMETROPIA.

An emmetropic eye is that in which when the eyes are in a state of perfect rest, parallel rays are exactly focused upon the retina, from ἔμμετρος, *modum tenens*, and ὤψ, *oculus*. It is "the standard by which the anomalies of refraction must be estimated." In the famous diagrams of the three kinds of eyes there is a slight exaggeration in the forms, that is, in the relative lengths of the three varieties in the refraction of the human eye, entirely justified for the purposes of teaching these funda-

FIG. 167.—SECTIONS SHOWING: I. THE NORMAL EYE; II. THE MYOPIC ONE; III. THE HYPEROPIC. (DONDERS.)

mental conditions, but which must be mentally modified by the practitioner in adjusting glasses. The line between emmetropia and hypermetropia, is not so well defined as it seems on looking at these figures. The investigations of the last twenty years have shown that, excluding the myopes, the vast majority, perhaps 96 per cent, of the human race is hyperopic. One writer, Van Fleet,[1] goes so far as to describe the hyperopic eye

[1] The Post-Graduate, vol. vii., p. 228.

as the normal one. He points out that a slight variation in length of the eyeball itself, cannot be considered an error of refraction, but that this is to be found in variations in the parts of the eye, that are really refractive media, as the cornea, the lens, and the vitreous humor. This is technically true, I think, but we should, after all, have a standard eye, a diagrammatic eye, while we keep well in mind, in practical deductions, that this is an ideal eye, as easily seen as is an ideal or standard human form, such as is chiselled by sculptors.

The average human eye, although hypermetropic, and having a low degree of corneal astigmatism, as we shall see, will do good work, without convex or cylindrical glasses, until presbyopia is preached. To attempt, as some authorities advise, to reduce every eye to the emmetropic standard, by placing glasses before it, is not a reasonable, nor will it be a successful, practice. It has led and will continue to lead to erroneous ideas of what may be expected from the use of glasses. The use of spectacles is a great boon to those who are myopic, presbyopic, considerably hyperopic, or to those who have a decided degree of astigmatism, but glasses will only fret and annoy those who do not actually require them. The burdens of myopia and presbyopia, are sufficient to those who are affected with them, without adding them to that great majority who do not require glasses, either for close work or for seeing at a distance. Since the discoveries of hypermetropia and corneal astigmatism, as would have been expected by the philosophic observer, the pendulum has swung too far. The tendency among oculists, and even among the educated community at large, has become in certain quarters too much inclined to ascribe all morbid sensations in the eyes, and many maladies of the general system, as due to uncorrected anomalies in the eye, and to prescribe glasses for them. It is not strange that this is so, when we consider the marvellous effects that have resulted from the exact rules that have been deduced from the discovery of the true nature of myopia and presbyopia, and the prevalence of hypermetropia and astigmatism. Unnumbered invalids have been relieved of distressing symptoms that were formerly thought to be incurable. Thousands of persons, who under the old ideas were condemned to disease of the eyes and to unintellectual pursuits, are now,

thanks to the aid of appropriate glasses, able to enter upon the occupations of their choice and to practise them in comfort. Scientific medicine has nowhere achieved more substantial triumphs, than in the field of the adjustment of glasses for imperfect vision. This is the result of the labors of a long line of workers, beginning with Young and Wallace, and culminating with Donders and Helmholtz. Having said all this, I would still caution my readers against the erroneous belief that a panacea for human ills is to be found in glasses, however accurately fitted.

Hypermetropia is divided into: 1. Manifest; 2, Facultative; 3, Latent; 4, Absolute.

MANIFEST HYPERMETROPIA.

Manifest hypermetropia is that form in which the vision for the distance is improved by convex glasses.

The average human eye, that is, the eye that is affected with a low degree of hypermetropia, say of one-half to one diopter, is not improved either by convex or concave glasses. Such an eye is less disturbed by a weak concave than a convex glass, but it prefers no glass at all. A simple test shows this. Let the patient be seated at a distance twenty feet away from the test cards, and having determined that the vision is not quite or nearly normal, if with convex glasses it becomes $\frac{20}{20}$, we may be sure that we have a case of manifest hypermetropia. Such persons are usually asthenopic, if engaged in using their eyes in close work. Perhaps not all of them; but the practitioner may advise the use of convex glasses for close work with great confidence of success in relieving asthenopic cases, if on trial the conditions above described are found. It was this class, to which the discovery of the nature of hypermetropia became such a boon.

FACULTATIVE HYPERMETROPIA.

Those who see equally well at a distance, either with or without convex glasses, may be said to be affected with facultative hypermetropia. This also constitutes a class separately less in number than those affected with manifest hypermetropia. They do not suffer from asthenopia in any such proportion as those having manifest hypermetropia. They may go on to the forti-

eth or even a later year of life without needing the aid of glasses. But they too, when affected with asthenopia, will usually be relieved.

LATENT HYPERMETROPIA.

This condition may be absolutely diagnosticated by the use of a mydriatic strong enough to paralyze the ciliary muscle. Many authorities prefer homatropine and use the drug on the eye every ten or fifteen minutes until complete paralysis is secured. This may be known by testing the patient with strong convex glasses, say of six or seven diopters. When the patient, after instillations of homatropine, is only able to read very fine type (No. 1 Jaeger) at the focal distance of the lens, there being no range of accommodation, we may know that complete paralysis is secured. I very seldom use a mydriatic to estimate the refraction, for reasons that will be fully given in the chapter upon astigmatism. In the rare cases in which I now use such an agent for paralyzing the accommodation, I prefer the sulphate of atropia, in a solution of four grains to the ounce of water. Such a solution will perfectly paralyze the accommodation in about forty-eight hours, if a drop be used three times a day. In my hands it is more certain than homatropine, although its use is much more troublesome because the full effect does not wear off for a week at least, sometimes not for ten or twelve days. A large experience with measurement of the refraction has convinced me that those who do not use the ophthalmometer may be certain to accomplish the desired effect with sulphate of atropia thoroughly used.

The use of atropia for testing the refraction has the disadvantage that it stops the action of the ciliary muscle, so that the corneal astigmatism may be overestimated. For example, if there be a corneal astigmatism of half a diopter, it is in an ordinary eye, not under the influence of atropine, neutralized by the action of the lens; but paralyze the ciliary muscle, and this neutralization does not occur—hence the patient will choose a cylindric glass under the examination made with a mydriatic, when, without one, he will not, and, as we shall see, it is better not to attempt to neutralize a corneal astigmatism of one-half a diopter.

PRECAUTIONS IN USING ATROPIA.

There are certain precautions to be observed when atropia is to be used for the purpose of paralyzing the accommodation.

1. The patient should be warned that the sight will be very much blurred for all distances, and that close work will be impossible when the drug begins to have an effect.

2. The atropia should be used in the outer part of the conjunctival sac, so that it may not pass into the punctum, and thus enter the nasal duct. In cases where this occurs, troublesome and, in extremely rare cases, alarming symptoms may occur from the constitutional effects of atropia.

3. The symptoms of belladonna poisoning are less likely to occur, if the mydriatic be instilled just after a meal.

4. In very bright weather, the patient's eyes should be protected while he is in the open air or a light room, by colored glasses. For a number of years, in all cases in which spasm of the accommodation was believed to exist, I employed atropia to determine the exact refraction. Although it is a very troublesome method both to the patient and to the surgeon, it is always to be relied upon.

After a thorough paralysis of the accommodation, with a little patience, even the beginner may be sure of determining the exact condition of the refraction. The rules for prescribing glasses in hypermetropia after this has been settled will be hereafter laid down.

Those who are skilful by long practice with the ophthalmoscope, may generally settle upon the refraction with sufficient accuracy and learn the degree of latent hypermetropia without the use of a mydriatic. But even the most practised observers sometimes make serious mistakes in their estimations of the degree of the hypermetropia, on account of the inability to relax their accommodation and to cause the patient to do the same. For the determination of astigmatism, I consider the ophthalmoscope entirely unreliable, and I do not advise its use for that purpose, although in cases of a high degree it is easy for an observer with any practice to determine that astigmatism exists.

By *axial refraction*, the length of the eyeball from the cornea to the retina is meant.

Spasm of the accommodation is a very rare affection. When it does occur, it is almost always easily determined. Such patients, when examined with the ophthalmoscope, are evidently hyperopic, although they accept concave glasses, and secure excellent vision with those of very low power. This subject will be more fully discussed a few pages further on.

After having determined the total refraction of the eye, in a state of rest, we have a standard by which we may decide what glasses are to be prescribed. It should first be stated, and I place great emphasis upon this statement, because the practice among many authorities has been quite different, that glasses are not to be prescribed which the patient is to wear constantly, unless the vision is markedly improved by them, or they are to be worn to relieve spasm of accommodation. For example, if a patient has vision $\frac{20}{20}$ or even fully $\frac{20}{30}$ but no more, the inconvenience of constantly wearing glasses will not at all compensate for the trouble and worry caused by them. The standard $\frac{20}{20}$, as we have seen, is only approximate. Many young subjects, and some middle-aged ones, have $\frac{20}{15}$, others again have only $\frac{20}{20}$, and yet no anatomical lesion can be found, while the difference in ordinary vision as to human faces, signs on the street, and so forth, is of no account. But convex glasses are very often prescribed for persons suffering from true or false asthenopia, with a view of lessening the fatigue in using the eyes upon distant objects, or with a view of relieving certain symptoms of nervous disease. That glasses ever do this for persons having normal vision, except in entirely exceptional cases, I deny. There are certain young, neurotic individuals who having been informed that they must wear glasses all the time, in order to get well, do wear them in this manner, although they have perfect vision without them I admit, but in this case I must regard the relief as a matter of cure by suggestion. Over and over again, I have had the satisfaction of telling patients, for whom their constant use had been prescribed, that they might dispense with them, except when at close work. They have been, almost without exception, very grateful for what was relief from a mild form of bondage. It is only in a high degree of hyperopia, that is, one

of from two diopters upward, that the vision even in middle-aged subjects, never in young persons, is impaired for the distance from this cause, and it is only for them, which generally include the rare cases of spasm of accommodation, that glasses both for a distance and near are to be prescribed in hypermetropia. In the low degrees of hypermetropia there is no abnormal tension upon the ciliary muscle, except in vision for near objects.

But having determined the axial refraction and the astigmatism, as may be done by the use of atropia and retinoscopy, we may prescribe according to rules, which experience has deduced.

1. In young persons we should generally leave, at least, one diopter, perhaps two, or even three diopters in some cases of the total hypermetropia uncorrected.

If the patient prove to have, for example, three diopters of hypermetropia, a glass of two diopters will be just strong enough, possibly one of one and a half diopters.

2. In a middle-aged or elderly person, that is, one of forty years or upward, the total hypermetropia may usually be corrected, with an added glass for the presbyopia, according to its state of advance.

3. It is not necessary to paralyze the accommodation in order to measure the refraction of persons over forty years of age. Their refraction can be accurately measured with test glasses, after that time of life, without the use of any mydriatic whatever.

In order to avoid confusion in the mind of the reader, I have, as yet, said nothing on less important forms of hypermetropia.

I.—ACQUIRED HYPERMETROPIA.

This exists in a high degree in eyes from which the lens has been removed, *aphakia*, except in cases of high degree myopia, when even the removal of the lens is not sufficient to convert the eye into a hypermetropic one.

There is also, in the opinion of Donders, a diminution of refraction in advanced life, say beginning at sixty years, quite apart from true presbyopia. This change should be carefully excluded from a low degree of hypermetropia which has been overlooked in middle age. When this is carefully done, I think there will be very few cases left of *hypermetropia acquisita*.

When it does occur, Donders believes it is due to changes in the lens, which have lessened its refractive power; a swelling in the lens which has increased its refractive power is not entirely uncommon. This constitutes what is often called *second sight*, occurring in old persons. By it, the failure of accommodation is atoned for and the fortunate subject is able to read fine type without glasses. Donders explains diminished refraction occurring in old age, by the fact that the several layers of the lens become uniformly more firm, and he quotes Thomas Young[1] to show that on account of the layered structure of the lens, which causes the refractive power to diminish toward the periphery, it has a shorter focal distance than a lens of similar form and wholly composed of a substance like that of the nucleus of the lens, would have. He goes on to say, that if the outer layers of the lens become more solid with advancing years, the focal distance of the lens increases. Further investigations upon this subject would be of service.

II.—ABSOLUTE HYPERMETROPIA.

By absolute hypermetropia is meant such a low degree of refraction of the eye, that neither distant nor near objects are ever seen without the aid of convex glasses. Such eyes generally give evidence in their external appearance that they are actually shorter than the normal eyes. These cases should be classed as abnormal eyes, but this is not true of low degrees of hypermetropia. Such eyes, as Donders[2] says, have a peculiar physiognomy, caused by the flat sclerotic, the shallow position of the iris, the relatively small pupils, and the appearance of divergent strabismus. The facial appearance is also modified by the shallow orbits, and the flatness of their edges, and the want of roundness of the cheeks. This characteristic appearance is, however, often wholly wanting, even in a considerable degree of hypermetropia. So that while we may assume that it exists with the presence of such conditions, it may be found with no marked facial appearances. It is to be remembered that the larger part of the world is born hypermetropic, as Ely's[3] sta-

[1] *Loc. cit.*, p. 206. [2] Archives of Ophthalmology, vol. ix., No. 1, p. 20.
[3] Archives of Ophthalmology, vol. ix., No. 1, p. 29.

tistics of the eyes of the newly born first plainly indicated. Von Jaeger fell into the unaccountable error from his investigations, of teaching that myopia was the more frequent condition in infancy. It is only when hypermetropia becomes of a considerable degree, say more than one diopter, that it can be fairly classed with abnormal conditions. But, as Donders pointed out, even a low degree of hypermetropia as the individual approaches the time for the appearance of presbyopia, requires correction for reading and similar purposes. This and the occurrence of one diopter of corneal astigmatism, with the rule, or of less than that even, against the rule, is the explanation of the fact that many people require reading-glasses before they are forty. If they escape until then and have a considerable degree of hypermetropia, the glass to correct this, must be added to the one needed by a person with a low degree of hypermetropia, who has come to be presbyopic. For example, the glass usually required for a person between forty and forty-five years of age, who is not myopic, and who has less than a diopter of hypermetropia and no astigmatism, or less than three-quarters of a diopter, is 0.50 D., while a person with a diopter of hypermetropia will need 0.75 or 1 D. for the first glasses. As will be seen in the discussion of astigmatism, the correction of this is especially important when presbyopia presents itself.

Heredity plays an important part, as it does in all the conformation of the human body, in the existence of hypermetropia of a high degree. Absolute hypermetropia and manifest hypermetropia exist in certain families, just as do myopia and astigmatism, and anisometropia—*difference of refraction in the two eyes*. There are hypermetropic and myopic and astigmatic families. All cases of manifest hypermetropia, are better off for wearing glasses for near and some also for distant vision, but the latter should not be insisted upon, unless the vision is absolutely bad without glasses. If, for example, a patient has a manifest hypermetropia of even two diopters, and yet has $\frac{20}{30}$ vision, or in some cases only $\frac{20}{40}$, and is content with this vision, disliking to wear glasses constantly, we may omit them. I have satisfied myself, after long experience, that the advantage gained by converting such an eye into the standard or emmetropic, is often purely imaginary, and gives patients much dis-

comfort. But for reading and all work upon near objects, patients should wear glasses. Then again children and young persons with low degrees of hypermetropia, or of astigmatism, may often be made much more comfortable by being freed from various forms of asthenopia in wearing glasses during their school life, who afterward, when their growth is finished, discard hem until the appearance of presbyopia. The practitioner should, however, not lightly prescribe glasses in low degrees of hypermetropia, or in corneal astigmatism of less than three-quarters of a diopter, but carefully examine into the general health and habits, the existence of anæmia, malaria, and so forth, before he condemns the patients to the bondage of glasses.

To Professor Hansen-Grut, of Copenhagen, the credit should be given of having been the first to forcibly bring to the attention of the profession, that even proper and full correction of hypermetropia of a considerable degree will not always relieve the asthenopia, for which Donders believed he had found a complete remedy in convex glasses. But the claims of Donders were certainly in the general view entirely correct, if we keep his definition of asthenopia well in mind, when wishing to know what we may expect from glasses. Disciples often go far beyond the master in their teachings. This has been notably the case in the treatment of asthenopia. If every beginner in the practice of ophthalmology, would make Donders' text-book his standard on the subject of errors of refraction and accommodation, many mistakes would be avoided. No book written since the publication of his treatise, will enable the special student and practitioner to dispense with it.

SPASM OF ACCOMMODATION.

Spasm of accommodation is excessive tension of the ciliary muscle. This converts a low degree of hypermetropia, or even a high one, into emmetropia or even into myopia.

As has been said, it is a rare affection and occurs almost exclusively in young persons, especially in those in school or college. Such patients suffer not only from asthenopia, but also from inability to see at a distance, and are relieved momentarily and even for hours and days, by wearing concave glasses, when their eyes are actually hypermetropic, or they have hypermetropic as-

tigmatism. It is of itself a suspicious circumstance when a young person on being placed before the test types, and being found to have a visual power of say only $\frac{20}{50}$ or $\frac{20}{70}$, immediately has $\frac{20}{20}$ or $\frac{20}{15}$ with a weak concave glass. Especially is this true if the asthenopia and defective vision have come on suddenly. An examination as to the refraction with the ophthalmoscope will soon establish the real state of the case. Any considerable degree of hypermetropia is, of course, utterly inconsistent with such a state of things. But it should be borne in mind that there are some cases of actual as well as artificial myopia, as that dependent upon spasm of the ciliary muscle is called, that come on with a bound as it were. In myopic families, I have often seen a child who was hypermetropic up to even six or seven years of age, suddenly develop amblyopia, which even the most thorough use of atropia did not overcome, but which was corrected by weak concave glasses. In these cases this is the beginning of an acquired myopia. No child of myopic parents, or even when one parent is myopic, may be said to be free from the dangers of myopia until puberty has been reached without it. Then again, even practised observers with the ophthalmoscope, often make out a low degree of hypermetropia to exist, or emmetropia, when the use of atropia shows that the refraction with complete paralysis of accommodation is actually myopic. The observer should therefore be guarded in statement, after one examination of a case of apparent spasm of accommodation and artificial myopia. The use of a mydriatic may show it to be one of actual myopia. If, however, the ophthalmoscope shows a high degree of hypermetropia, or the ophthalmometer more than one diopter of corneal astigmatism, the observer may be nearly certain that he has a true case of spasm of accommodation. Spasm of the ciliary muscle only occurs, however, in persons of less than forty years of age, and rarely except in persons between the ages of eight and twenty-five. It is entirely wrong to use a mydriatic for the prescription of glasses in any person over forty years of age. It is very rarely necessary in any case, if the existence or non-existence of corneal astigmatism be made out with the ophthalmometer. If spasm of accommodation be found to exist, in order to overcome it it will be necessary to use the sulphate of atropia in a solution of the strength of four grains to the ounce, three

times a day for several days and in entirely exceptional cases for weeks. The proper convex glasses should then be adjusted, and the patient, who will find great relief from them, advised to wear them constantly. If the spasm disappear, and vision become $\frac{20}{20}$ without them, the general rule should be followed, and they be worn only for close work.

Spasm of accommodation may be studied by the use of the calabar bean, as it was when this myotic was discovered (Argyll Robertson). It is then accompanied or moderated by a feeling of tension in the eye, amounting to pain. There is a natural tone or tonicity in the action of the ciliary muscle, as well as that of the other muscles of the eye, which should not be mistaken for spasm. The letting up of the tonic contraction by the use of atropia and consequent paralysis of the accommodation, will reveal a low degree in all eyes not myopic of what may be called, strictly speaking, latent hypermetropia, if we have too high a standard for a normal eye, say, 0.25 to 0.50 D. This, however, should not be considered as any indication for prescribing glasses, nor as any evidence of spasm of accommodation. Nature allows considerable latitude in the workings of the different parts of the human organism. The practitioner will be wise if in this and in other respects he follows her guidance. As has been intimated, the hypermetropic eyes of infants develop in a large proportion of cases. In some myopia occurs. In others the degree of hypermetropia is lessened. There is, however, no eye that may not be lengthened in its axis as life goes on. There is, in other words, no eye that is born exactly emmetropic, and which remains liable to no changes.

The eye born myopic, or which becomes so in early life, is the one more likely to increase its axial refraction. The cornea may also undergo changes that increase its astigmatism. Conical cornea is an exaggerated condition of this kind.

CHAPTER XXVIII.

MYOPIA.

Definition.—Artificial Myopia.—Myopia Dependent upon Axial Elongation.—Nomenclature.—Progressive and Non-Progressive.—Remarkable Case of Non-Recognition of Myopia by the Patient.—Congenital Myopia.—Statistics of Myopia in Schools.—Myopia a Condition of Civilized Races.—Diagnosis.—Ophthalmoscopic Appearances.—Fitting Glasses.— Posterior Staphyloma.—Remote Causes of Myopia.—Treatment.—Correcting Glasses.—Influence upon Character of Uncorrected Myopia.—Radical Cure of Myopia.—Removal of the Lens for the Cure of Myopia.—Transient Myopia in Connection with Iritis.—Dr. A. Schapringer's Explanation of the Proximate Cause.

MYOPIA (μύω, to blink) *is that state of refraction, in which parallel rays come to a focus in front of the retina.* The myopic eye is adapted for divergent rays, those that come from near objects, and which may be produced by dispersing concave lenses. The anatomical cause for this defect, is usually an elongated axis of the eyeball, from before backward. This is the standard form of myopia. Myopia may also depend upon too great a curvature of the cornea. This is generally the result of disease, although it may be congenital. It is also caused by swelling of the lens. This latter form of what may be called *artificial myopia*, as we have seen, occurs chiefly in old age, and is popularly known in its results, the patient being often able to read and sew, and so forth, without glasses, as *second sight.* Spasm of accommodation also produces artificial myopia. Our present discussion, however, chiefly concerns that which is dependent upon axial elongation of the eye. Its careful study is of great importance to the practitioner, for it is an anomaly of refraction that causes such inconvenience, and which, in many instances, leads through various morbid conditions, to great impairment, or even total loss of sight. A considerable percentage of civilized communities is affected with this condition. In some countries it has been denominated an actual scourge.

The investigations and study of our time, have led to prevention and curative resources, which it is to be hoped will diminish its frequency and lower the average degree to which it would advance were it not for the law that the tendency in nature is to return to the original type. Germany, at least, might fear that in the progress of the centuries, a large proportion of her people would become disabled by myopia. She holds the front rank among the nations as a myopic race.

Myopia is popularly known as short-sightedness, the name being taken from the inability of those afflicted with myopia to see, except at short range. It is a name better adapted to the actual condition than the scientific one. Scientific endeavor has been used to give to myopia a name in accord with its anatomical origin. The present name is taken from a symptom that is seen among those who are myopic, especially those who have myopia of a high degree. As is well known, myopes contract their eyelids, blink, in order that they may diminish the number of rays entering the pupil, and thus make their sight better.

Hypometropia (ὑπο, under the mean or measure) and *brachymetropia* (*brachus*, μετρον) are terms (Donders) that have been proposed as substitutes for *myopia*, but the latter name is so thoroughly well grounded in our nomenclature, that it is too late, or too early, to make a change.

In the same sense that absolute and high degrees of hypermetropia, may be said to be a disease of the eye, so is myopia, when it reaches a high degree. Since, however, myopia is very apt to advance, especially in the early years of life, and as it may occur at any period, it is a condition involving more danger to the sight than hypermetropia. It has been claimed that myopia may be divided into the progressive and non-progressive. In a sense this may be true, but if it is meant by this that an examination of a given case of myopia, by an expert, can determine anything more than the probabilities as to the progressiveness of the myopia, I am, from my experience, adverse to this view. A careful study of the heredity of the patient, with the occupations and habits, general health, surroundings, together with the condition of the vitreous humor, the optic nerve and retina, may, it is true, help us to form a prognosis in given cases, but there are exceptions which put all

rules at defiance, so that we cannot always positively say to which class a case of myopia belongs, although there is a progressive and non-progressive variety.

One of my patients who was formerly a cadet at West Point Military Academy, but who was obliged to leave there on account of advancing myopia in one eye, appeared first at sixteen years of age, when he had hyperopic astigmatism in one eye and myopic in the other, but he soon had myopia combined with his corneal astigmatism, and was obliged to wear concave cylinders in consequence of the increase of the myopia. His experience—he is now a medical student—was very interesting, as related to me, he being a very intelligent young fellow. He said that he was obliged to wear his correcting glasses all the time, but when a morning occurred in which four hours of consecutive lectures were given, he began to have a blur before his eyes, and, to use his own language, "a regular aura," which preceded a headache, and, what is rather more extraordinary, salivation about a half an hour before the headache came on. The relation between migraine and myopia is always of interest. It must have its origin in the taxing of the ciliary muscle. I advised this young man not to stay many consecutive hours in the foul air of the lecture-room, which had been used continuously by a number of students for four hours, to get more fresh air, and so forth. General hygiene comes in as of the greatest importance in the management of such cases. He is a spare, thin, neurotic young man. His father was in full middle age when the son was born, and is now a vigorous medical officer of the army.

Myopia is congenital to some degree, but not to such an extent as was at one time supposed. It more frequently de-

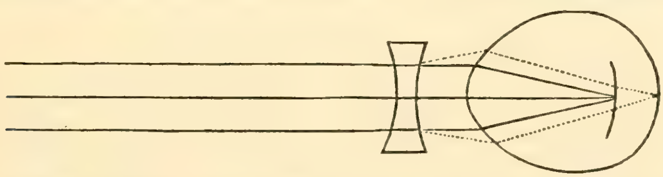

FIG. 169.—TO SHOW EFFECT OF A CONCAVE LENS TO CAUSE PARALLEL RAYS TO UNITE ON THE RETINA.

velops in the early years of life. I have many times observed the transition from hypermetropia to myopia in children, and this in those who were under good hygiene. This is usually in myopic families; at least, the father or mother or aunt or uncle were usually myopic.

Vast numbers of statistics have been collected as to the existence of myopia in schools (Cohn, R. H. Derby, Callan, and others). It has been conclusively shown that its appearance and increase in degree is a part of school life, in those who have a hereditary tendency to a myopic structure of the eye, what the Germans call a myopic *bau*.

Myopia, and often of a high degree, may also be found among people who are not engaged in intellectual nor exacting occupations, such as reading, fine sewing, or the like, nor in whose ancestors is there any likelihood that eyes have been used in this way. Dr. Kollock, of Charleston, in this country, found scarcely any myopia among the pure colored race (negroes) of the sea-islands near that city. Myopia is said to be rare among the native American Indians. All evidence indicates that it is usually a condition of civilized races, and that it is especially frequent among people devoted to books and writing, to close observation upon near objects. It may be said to be an aristocratic disease, in that it is proportionately frequent among cultured communities, with such exceptions as have been noted. It cannot be denied, however, that the general nourishment and development of the body involve the tissues of the eyeball, and that much of axial elongation is correctly to be ascribed to bad hygiene. One of the cities of this country, which has a large proportion of highly educated people, has a *Myopia* Club. Yet in England, where intellectual culture and life in the open air, go hand in hand, myopia is less frequent among the higher classes, than it appears to be in countries where less time is given to shooting, fishing, boating, cricket, and so forth. Statistics on this general subject of the relative frequency of myopia in civilized and uncivilized communities, and then as to the kind of occupation that may be said to favor its production and increase, except among school children, are still wanting.

Diagnosis.—The diagnosis of myopia may be made in a rude and not always accurate way, by the following test. The patient is first tested as to his ability to see at a distance. This may be done with test types, or if they are not at hand, with the heading of such a newspaper as the New York *Herald*. If this heading cannot be read at twenty feet, test for the near vision may be applied. If there be no serious disease of the

retina, and the eyeball be simply elongated, the subject who is merely myopic will be able to read the very finest type, and see the very finest objects with great facility. But inasmuch as there are cases in which the patient has a myopic structure of the eyeball, and yet sufficient disease to cause inability to read fine type, or to see very fine objects, this test is by no means exclusive. It hardly deserves the name of a scientific test. In testing for myopia, the observer should carefully exclude latent hypermetropia, especially in young persons Then the test with glasses and the examination of the refraction with the ophthalmoscope, will determine the degree. The ophthalmometer will here, as in all errors of refraction, play an important part in determining how much, if any, of the ability to see at a distance may be due to corneal astigmatism. This defect is not at all so frequent in myopia as in hypermetropia, yet high degrees of myopic astigmatism do occur without axial myopia, and must always be looked out for. This infrequence of astigmatism is one of the reasons why true asthenopia is so infrequent in myopia. The practitioner who does not use the ophthalmometer, in all doubtful cases, should practise retinoscopy and use sulphate of atropia, in young persons, lest he mistake artificial for true myopia.

The cornea should also be very carefully examined for minute opacities, which result from ulcers that have occurred in infancy and early childhood, and which have been forgotten by the patient or the family. Certain cases that are amblyopic from this cause may be mistaken, on a hasty examination, for true myopia.

OPHTHALMOSCOPIC APPEARANCES.

In many cases of myopia, especially that of low degree, and in its beginning, there are no especial ophthalmoscopic appearances. But those who are experts in the use of the ophthalmoscope for the measurement of refraction, can usually correctly measure the degree of myopia with that instrument. Besides this, it is characteristic of a myopic eye that the details, entrance of the optic nerve, optic papilla, veins and arteries, pigmentation of the fissures, can be seen at some distance away, if the *direct* method of ophthalmoscopy be employed. In very

high degrees of myopia, it is better to employ the indirect method for careful study of the condition of the retina and choroid, because a very strong glass must be used to see by the direct method. In using the ophthalmoscopic mirror, when the head of the observer is moved to one side, the blood-vessels are seen to move in the contrary direction. This is due to the fact, that in myopia an aerial image of the fundus is formed by the refractive media of the eye itself, at a distance corresponding to the degree of the existing myopia. For example, in a case of myopia of three diopters, at about twelve inches from the eye, if the observer be nearly emmetropic, to get a clear image of the details of the fundus, a concave glass to neutralize the myopia of the eye being observed must be used. The focal distance of this glass, added to its distance from the nodal-point of the eye being observed, equals the degree of the myopia. But the glass used to correct the myopia in the eye observed expresses, for all practical purposes, the number of the proper correcting glass, for it is held at about the same distance from the eye as the correcting glasses for the patient's use will be. It is only when the observer wishes to estimate the refraction with entire accuracy, that the distance between the glass and the nodal point need be considered. It is to be remembered that in myopia the correcting glass is stronger, and in hypermetropia weaker, than it would be if it could be placed at the nodal point. If the fundus be seen clearly through a glass of 4 diopters, held away 2 inches, $\frac{1}{18} = \frac{1}{6}$, the real degree of the myopia $= \frac{1}{6} + \frac{1}{18} = \frac{4}{18}$ or $\frac{1}{4\frac{1}{2}}$ = about 9 diopters. In hypermetropia, under the same conditions, the hypermetropia would be $+ \frac{1}{6} - \frac{1}{2}$ 6 D. $-$ 18 $=$ 12 D.

In fitting myopes with glasses, as will be seen, we choose the weakest glass that brings the vision up to the proper standard. Just so in measuring the myopia with the opthalmoscope, we estimate its degree by the strength of the weakest glass with which the details of the fundus remain clear and well defined. Loring's tables of the actual lengthening of the eye, in various degrees of hypermetropia and myopia, tables which he calculated from the formulas of Helmholtz, are very interesting to those who make much of measuring the refrac-

tion with the ophthalmometer.[1] Nowhere is this more important than in young persons who seem to have myopia, but in whom the ophthalmoscope finds not only hypermetropia, but that of a high degree. Loring believed that hyperopes of a high degree were much more apt to relax their accommodation during an ophthalmoscopic examination, than those having a low degree, less than 0.50 D. His reasoning is very plausible. He says that hypermetropes of a high degree often relax their accommodation entirely, while looking inattentively, at a distance, and make no attempt to call it into play until their attention is aroused. Consequently, when being tested by glasses, they call upon their accommodation to decipher the smaller letters of the test card, but when placed in a darkened room, and told to look at a wall with no objects upon it, and which will appear to them but a very little less clear, when seen through circles of dispersion, they easily and preferably relax their accommodation; but young persons with less than 0.75 D. of hypermetropia, Loring thinks, never relax their accommodation, because they prefer to make some strain on the ciliary muscle, to seeing in circles of dispersion.[2] I have no difficulty in accepting Loring's views on this subject. It is very fortunate for the observer that they are true, and that the expert in ophthalmoscopy, will not be in danger of mistaking spasm for true myopia, without the aid of atropia.

POSTERIOR STAPHYLOMA.

There is a condition of the fundus almost entirely peculiar to myopia, which deserves especial consideration in all cases, as to its presence or absence, its magnitude and details. This is the so-called posterior staphyloma, or the myopic crescent, also sclerotico-choroiditis posterior, sclerectasia posterior. This is due to the elongation of the eyeball caused by stretching and inflammation of the retina and choroid at this point. It leads to atrophy of the tissue which gives the peculiar appearance. The observer should examine eyes beginning to be myopic, for the mapping out, as it were, of this condition, since it forms quite an element in the prognosis. It usually occurs in highly

[1] "Text-Book of Ophthalmoscopy." [2] *Ibid.*, p. 112.

myopic eyes only, and leads to a further increase in the myopia. Sometimes it becomes so large as to invade the macula lutea, which of course, causes great loss of sight, or even total destruction of central vision. The predisposition to posterior staphyloma seems to be congenital. It may be, happily for the patient, stationary. The crescent is then seen, as a more or less regularly curved crescent at the outer side of the optic disc, or it may be a zone extending nearly or quite around the disc, of a glistening white color. This color is from the sclerotic, showing through the atrophied choroid. The edges of the crescent or zone, as the case may be, are well defined and fringed with pigment. The retinal vessels are seen running over it. The myopia does not increase in such cases, and the eye is, consequently, not painful or irritable.

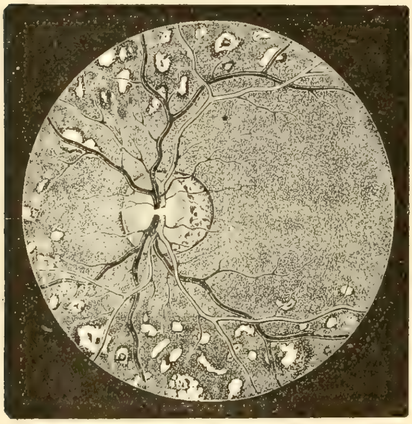

FIG. 170.—POSTERIOR STAPHYLOMA IN THE MYOPIC EYE, WITH DISSEMINATED CHOROIDITIS.

But, if the process be progressive, inflammatory symptoms are added to those just described. The edges of the crescent are congested and indistinct, additional white patches appear, and are united to the original, the vitreous humor becomes turbid, and the vision is impaired beyond the power of concave glasses to improve. Choroidal hemorrhages, detachment of the retina, and, exceptionally, glaucoma may be added to the myopia. It is all this, which causes such concern in cases of myopia of a high degree, or in the progressive form of the disease. An inability to continue to use the eyes (asthenopia) in a myopic patient is always a more serious matter than the same symptoms occurring in hypermetropia, for it is often merely a sign of chroidal irritation or inflammation.

REMOTE CAUSES OF MYOPIA.

If we can imagine a state of things in which it is desirable to make a myopic eye, the following-named conditions would

do it. The rather fanciful picture may serve to give an idea of the principles involved in the prevention of myopia. If a child be born of myopic heredity, and be besides not well nourished, begin at an early age to use the eyes on fine objects, especially if with poor illumination, and with no regard to its position with reference to the light and the object, and not have a full amount of exercise in the open air, and all general hygienic conditions be neglected, we may certainly expect myopia. The anatomical situation of the beginning of the condition is the ciliary muscle. This becomes congested from the strained accommodation. This strain occurs in consequence of the constant effort to get a clear image upon the retina. The ciliary region finally softens and gives way and the eyeball is lengthened (Arlt).

Undoubtedly uncorrected errors of refraction may lead to this condition, and it may occur, when the hereditary predisposition is marked, in hearty children when every known hygienic precaution seems to have been observed. Yet, in the vast majority of instances, myopia occurs in families where much remains to be desired in general physical development.

Treatment.—In view of the importance of myopia, if progressive, to the ultimate vision, the physician cannot be too much on his guard to prevent its outbreak or increase in the families under his charge. Parents who are myopic, should be warned of the dangers to their offspring, of the objects upon which the eyes are to be used, the character of the illumination, and the position in reading or sewing, or the like. The physical development should be well looked to, and whenever physicians can exercise any supervision over school-rooms and school-hours, they should do so, in order to secure an abundance of daylight, a proper position of the pupils at properly constructed desks, and so forth. A wide-spread recognition of the dangers of myopia on the part of Boards of Health and school authorities, will do

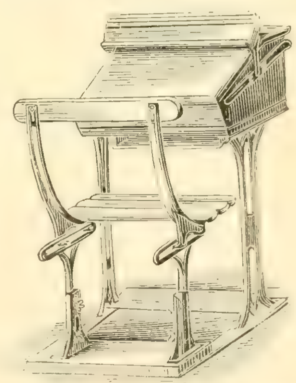

FIG. 171. — MODEL OF A PROPER SCHOOL-DESK FOR GROWING CHILDREN. (COHN.)

much to prevent a country from being afflicted with what may become a real calamity to the commonwealth, as well as to the individual.

CORRECTING GLASSES.

There is, in spite of all that science has promulgated in this respect, a prejudice against correcting glasses. It seems extraordinary at first thought, that any person whose vision is imperfect will regret a means of making it perfect, but those who from youth to mature age have seen nothing except in what a myopic and artistic lady, once described to me as "a beautiful haze," very often decline to wear glasses which bring out everything with a startling and, to some, an unpleasant distinctness. They complain that the features of their friends have lost their charm to them, because of the lines and furrows and defects which were formerly unnoticed. This state of mind does not possess all. Even mature persons and young persons in school, who cannot see the figures on the charts and blackboards of the recitation-room, hail with delight that assistance which puts them on an equality with their fellows. It has long been since observed and commented upon by Donders and Loring, that character may be influenced very materially by the existence of uncorrected myopia. We will imagine that a boy or girl who never sees the moon or stars, or even the face of a friend distinctly, unless he is very near to him, who can learn nothing of the beautiful details of the trees of the forest, or the lilies of the field, must grow up to a very different manhood or womanhood, than one who has always unconsciously almost enjoyed the study of the play of expression on a human face, and the beauty of the sky, the fields, and the flowers. But the individual human mind compares the vision of others with its own with very great difficulty. Many who see very badly at distances, say what we mathematically express by $\frac{20}{70}$ or $\frac{20}{50}$, are utterly unaware that they do not see quite as well as any one, so consumed are they by their capacity to see the finest objects and to continue to use their eyes without limitation of time, and so ignorant are they of what others see.

Then again, myopes learn certain little devices by which they recognize objects which seem to be beyond their visual

capacity; a large feather, or other distinctive mark on a friend's bonnet, of a lady, and other similar distinguishing marks of considerable size enable them to perform actual feats of vision, which, with blinking, enable them to scorn the assistance of glasses. So unobserving is the world in general as to their functions, unless some serious interference with their performance occurs, that intelligent people will sometimes be told for the first time, when such an occasion as adjusting glasses for presbyopia occurs, that they cannot read fine type with one of their eyes, nor see more than half as well at a distance with the other. Among the less intelligent, even, great objects sometimes pass unnoticed, until blindness has set in. A lawyer cross-examining an oculist in court, once became very indignant because the witness stated that he had seen many tolerably intelligent people, with some education, who could not tell anything accurately about their vision; but the oculist was right and the lawyer wrong. Persons sometimes come for examination who declare they see quite well with an eye with which they are unable to count figures a foot away, and others can scarcely be induced to tell what they actually can read of the test letters, but impatiently answer, "Oh, I can see all of them," when they, perhaps, can read only $\frac{20}{200}$, or even less. Many people mean that they can *see* that of which they can make out the color and bare outline, without being able to define it as a given object, or a letter of the alphabet.

As an illustration of the want of knowledge of many persons as to their comparative vision, the following striking case from the practice of Dr. Van Fleet is adduced:

Mrs. M. L., aged 25 years. She is one of a large family. As far as she knows, none of them ever had any trouble with their eyes. She knew she was unable to see objects clearly unless she approached very close to them, but she supposed everybody had the same difficulty. She never thought of anything being the matter with her eyes, until her marriage and after the birth of her first child. She then observed one day when holding her baby on her lap that she could not see the color of its eyes. When she consulted her physician, he referred her to Dr. Frank Van Fleet, who found that her vision on the right side was $\frac{20}{200}$. With a glass of -14 D. it became $\frac{20}{50}$. In the left eye her vision was $\frac{20}{2000}$, and with a -16 D. it became $\frac{20}{30}$.

The wearing of these glasses caused the most profound astonishment. The patient had no idea that any one ever saw so plainly as she is now able to do. This patient was a woman in comfortable circumstances, of intelligence and education. Hundreds of such could be found by looking over the case-books of oculists, and many more who never have consulted an oculist, never have worn a glass, but are perfectly content with their own sight.

There are hardly any exceptions to the statement that myopia that does not allow a person to see more than $\frac{20}{40}$, and that without blinking, ought to be corrected. A vision of $\frac{20}{30}$ may well be left uncorrected, if the subject so desire. Myopes usually read without glasses. This, of course, they can easily do, since the rays of light are more divergent the nearer the object, and their long eyeballs are adapted to this condition of things. There is no objection to this, if the myopia be not of so high a degree that the objects upon which the eyes are to be fixed, must be brought nearer than eight inches from the eye. The danger of increase of myopia, as has already been said, rests in stooping the head and shoulders, and, consequently, overfilling the ciliary muscle with blood, and preventing its free circulation. Patients with a high degree of myopia, ought to wear glasses from morning until night, in all occupations. Usually the glass that is adapted for distant vision will be the one required for this purpose. There is more danger of too little aid to the ciliary muscles and internal recti, than too much. It is often the case that myopic subjects cannot bring themselves at once to tolerate a full correction, but it is by no means certain that they will not ultimately be more comfortable with these than with any other. I am more and more in the habit of advising a full correction, and that the glass be worn for all occupations, as being the most likely means of securing the comfort of the patient and guarding him against the dangers of progressive near-sightedness.

Patients with a high degree of myopia, and one diopter of astigmatism, do not generally care to have the astigmatism corrected. They probably correct it unconsciously by a position of the head or of the glass, and I do not urge the correction of an astigmatism of one diopter in a case of myopia of six diopters or more, unless the patients prefer it. But I endeavor to induce

them, by careful and repeated trials, extending, if necessary, over a considerable period of time, to wear glasses that fully correct the myopia. The reader may remember that this is the reverse of the advice for latent hypermetropia, or even for manifest of a low degree.

In prescribing glasses for myopia, the morbid conditions of the eyeball that may exist come very much into consideration. There are many cases of advancing myopia, consequent upon inflammation or congestion, or irritation of some parts of the eye, especially in the ciliary region or the optic papilla, where all continuous use of the eyes upon near objects, must be given up, the patient sent on long voyages, a journey to rural life, or the like. But in speaking of adjusting glasses to myopes, we are speaking of those in which no marked symptoms of these conditions are present. A full correction, however, of the myopia for the distance is applicable even to such eyes. A patient with large floating bodies in the vitreous humor, and other evidences of choroiditis, is better off with his myopia corrected, for his going about and social intercourse, than without glasses.

RADICAL CURE OF MYOPIA.

The radical cure of myopia was much talked about before Arlt and Von Jaeger demonstrated its anatomical nature to be essentially an elongation of the eyeball, when the cornea and the lens were supposed to be the seat of its origin. Purkinje and Ruete[1] proposed to restore the proper curvature of the cornea by pressure, but now that we know the true nature of the elongation of the eyeball, such a mode of cure is properly regarded as absurd. Only a staphylomatous cornea in process of healing can be advantageously treated in this manner, and then not always successfully, but a healthy cornea never. When there is a very marked pressure of the muscles upon the eyeball, with occasional divergent squint, the externi may be divided and set back: but tenotomy, as recommended by those whom Donders found practising it in cases of hypermetropia mistaken for myopia, or as performed by a later school which to a slight degree had the sanction of Graefe the elder, should not be thought of. Latent insufficiencies, in other words, should not be meddled with by

[1] Donders, *loc. cit.*, p. 415.

operations. In early life even a very marked divergence at intervals should not be corrected by separating the muscle from its attachment. The operations are very often unsuccessful, and until puberty is reached, we cannot tell but that the patient may overcome the weakness of the muscle.

REMOVAL OF THE LENS FOR THE CURE OF MYOPIA.

What to say about the operation for the cure of myopia by the removal of the crystalline lens, is not so clear. The inconveniences, to use no stronger word, of a very high degree of myopia, say of twelve diopters, are so great and the dangers so imminent, that one may actually think of removal of the lens, as a way out of serious difficulties. Thirty years ago, the operation was condemned by high authority, but of late good reports have come from a very few cases. Were the dangers of extraction less, there could be no question of the propriety of the operation in extreme cases. I have, as yet, seen no case where I would be willing to advise the removal of the lens for the cure of myopia, but I am not at all certain that a case of advancing myopia, which is of a very high degree, would not tempt me to advise and perform an operation. That it can ever have any extended field is, however, extremely improbable, unless we may still further diminish the dangers of total loss of the eye from extraction of the lens. Those dangers, it should be remembered, are greater in the removal of a transparent lens than in the opaque one. Nothing need be said, to any extent, of the cure of myopia by the use of atropia. No such thing is possible. The cases reported of such a result are simply cases where the tonicity of the ciliary muscle has been reduced, or spasm of accommodation relieved. In the former case, the eyeball will return to its normal condition as soon as the use of the atropia is discontinued and its effects recovered from. In the latter, either a low degree of myopia has been over-estimated, or hypermetropia was mistaken for it. We have no means as yet of lessening the degree of true myopia.

The only real change that may occur is from the effects of age, when the lens may become of lesser refractive power, as will be observed in the discussion of presbyopia.

TRANSIENT MYOPIA IN CONNECTION WITH IRITIS.

In 1887 Dr. John Green called attention to transient myopia, occurring in connection with iritis.[1] He noticed during an attack of double iritis in 1867, occurring in his own eyes, that vision at a distance of 20 feet was greatly improved by concave glasses of about $\frac{1}{24}$. As he recovered, weaker concave glasses were sufficient to raise the acuteness of vision to its maximum, until about two months from the beginning of the attack the vision had become normal. Dr. Green made similar measurements upon other patients convalescent from iritis, and he found a similar change, amounting at first to 1.50 D., gradually falling off to zero in from a month to six weeks. Twenty years after the first attack, Dr. Green had a second in the left eye alone. As in the previous attack, the refractive change was a transient myopia of from 1. 50 D. to 1.75 D. Dr. Wadsworth confirmed this observation of Dr. Green's by those made on his own patients. Since that time, Dr. A. Schapringer has determined what he believes to be the proximate cause of this transient form of myopia, associated with iritis.[2] He remarks that he did not accept Dr. Mittendorf's explanation of this increase of refraction, made in 1888, that it was the result of an infiltration of the anterior portion of the vitreous body, increasing the bulk of this organ to such a degree as to push the lens forward. Dr. Schapringer rejects this theory, because he thinks that the suspensory ligament of the lens has such strength that an increase of pressure in the vitreous humor, must be very great to displace the lens forward. This, he argues, would cause the globe to be hard, and make it present other symptoms of tension.

Dr. Schapringer also rejects any augmentation of the corneal curvature as a cause, this having been disproved by the ophthalmometric measurements, and also, he rejects spasm of the ciliary muscle, on apparently good grounds. He believes that the transient myopia of iritis, is best explained by a temporary increase of the refractive index of the aqueous humor.

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[1] Transactions of the American Ophthalmological Society, 1887, p. 599.

[2] New York Medical Journal, October 21st, 1893.

It is a fact, he says, that the composition of the contents of the anterior chamber in iritis differs from that in the normal state. He believes this to be due to the deposit of fibrin upon the walls of the anterior chamber and aqueous humor. A higher index of refraction of the aqueous will produce short-sightedness, Schapringer thinks, because the beams of light which receive an inclination toward the optical axis, when refracted at the anterior corneal surface, will receive an additional inclination toward this axis at the posterior corneal surface. Accepting this hypothesis, as the true explanation of the myopia caused by iritis, the writer argues against continuing the instillations of atropine after the pupil has fully yielded to its action, and the congestion has subsided, although the myopia may still be present. He thinks a dilated pupil, kept up to long, might interfere with the drainage of the anterior chamber. If the myopia persists for some time after the subsidence of the inflammation, Dr. Schapringer recommends massage of the eyeball as a proper therapeutic measure. But he gives no cases in which this treatment has been adopted. He proposes to call this form of myopia "index myopia." He recommends the profession to settle the question by measurements with the ophthalmometer. Schapringer believes that the myopia caused by diabetes, is also index ametropia.

CHAPTER XXIX.

ASTIGMATISM.

Definition.—All Errors of Refraction Divided into Either Hypermetropia or Myopia.—Corneal Astigmatism.—Different Forms of Astigmatism.—The two Kinds of Aberration in the Course of Light.—Thomas Young, the Real Discoverer of Astigmatism.—Astigmatism With and Against the Rule.—Diagnosis.—The Disturbances to Vision caused by Astigmatism of a High Degree.—The Lenticular Astigmatism of Thomas Young.—The Degree of Astigmatism needing Correction, and that likely to Produce Asthenopia.—A More Important Element in the Production of Asthenopia than Hypermetropia.—Dr. Deynard's Tables of Non-Asthenopic Persons.—Donders' Statement as to What Amount of Corneal Astigmatism is Abnormal, and the Lessening of the same by the Lens.—Javal's Rule.

ASTIGMATISM (*α* privative, and *στίγμα*, a point). Definition: Literally, *that state of the refraction, in which, when the eyes are at rest, rays of light from a point are not reunited in a point.*

Astigmatism depends on a want of symmetry in the cornea or lens, or both. This causes the refraction to differ in different meridians. When the defect is of considerable degree, more than, say, one and a half a diopter, the confusion in the image formed on the retina cannot be overcome by the patient. All vision is blurred, while an examination will show that one set of lines, either vertical, horizontal, or oblique, is seen more distinctly. But one diopter of corneal astigmatism, if of the kind usually found in hypermetropia and myopia, may exist without any impairment of vision which can be detected, unless by a most exact examination by an expert.

All errors of refraction may be divided into either hypermetropia or myopia. Astigmatism exists with either condition. It may be in one meridian of the eye hyperopic, and in the other myopic. We may illustrate this by the following table:

1. Simple hyperopic astigmatism. In this one meridian is hyperopic, the other emmetropic, or more frequently only *very slightly* hyperopic.
2. Compound hyperopic astigmatism. Both meridians are hyperopic, but one more so than the other.
3. Mixed astigmatism. One meridian is hyperopic while the other is myopic.
4. Irregular astigmatism. One and the same meridian is of different degrees of refraction.

Myopic astigmatism is, of course, subdivided into simple and compound just as is hyperopic.

The discussion in this chapter chiefly concerns corneal astigmatism, for we know very little of that form which is dependent upon the lens. The latter is, fortunately, also of very infrequent occurrence, and need not greatly concern us in our investigation of the refraction of the eye. In a strict sense, as was pointed out by Van Fleet,[1] the cornea and the lens form the chief seats of errors of refraction, since they with the vitreous are the only parts of the eye that refract rays of light. We may some day recast the nomenclature of errors of refraction, but I do not think we are, as yet, justified in any more radical changes than those laid down by Donders, and those that have been already made in this volume. There is, however, a classification of corneal astigmatism upon which formerly little stress was laid, and which by some writers seems to have been unknown. This classification becomes of importance in the diagnosis by the ophthalmometer.

This is the classification of corneal astigmatism *with* or *against* the rule. More of this will be said a little later.

The late Astronomer Royal of England, Airy, described the defect as existing in one of his own eyes, and Reverend Dr. Whewell, of England, gave the defect its name. Whewell used the name only for the regular form. Donders applied the name to all forms, and in that sense it is generally employed.

Astigmatism, besides its division into terms defining the general conformation of the eyeball, is also divided into: (1) Regular; (2) Irregular.

[1] The Post-Graduate, vol. vii., p. 228 *et seq.*

The regular is that form in which each meridian continues the same in refractive power throughout its course.

The irregular is that form in which there are variations in one and the same meridians.

THE ABERRATION OF LIGHT.

The student of optics knows, but it may be repeated here, for the purpose of continuity and clearness of description, that there are two kinds of aberration in the course of light.

1. Chromatic. This results from a difference of refrangibility of the rays of light.

Rays which were originally parallel to the axis of a light-refracting surface, and also at an equal distance from that axis, undergo no aberration, in consequence of coming upon a spherical surface, and if they were of the like nature would remain directed exactly to one point. But rays of an unlike nature, find their focus in the axis, at different distances from the refracting surface, the violet and blue rays at a shorter, the red at a longer, distance. This is chromatic aberration as seen in the dioptric system of the eye. It scarcely interferes with the acuteness of vision.

2. Homogeneous light consists of the same length of waves. They are of equal refrangibility. The light is of similar color, and is so named, *monochromatic*. If such rays fall parallel to each other, upon a spherical surface, and at the same time at an equal distance from its axis, they are refracted in an equal degree from or toward this axis. They continue directed to one point. But if, although parallel to the axis, they strike the surface at different distances from that axis, they cease to be directed to one point. The farther from the axis they strike the surface, the nearer to the surface they cut the axis. This deviation is called spherical aberration of rays of one color. This one-colored aberration in the eye has reference to aberration in one and the same meridian, *irregular astigmatism*.

Then there is the aberration dependent upon the difference in focal length of the different meridians of the cornea, or of the lens, constituting the light-refracting system of the eye. This is regular astigmatism.

As has already been intimated, our concern as practical ophthalmologists is chiefly with the aberration as occurring on the cornea, or *regular corneal astigmatism*. It is for this con-

dition that we may prescribe with very considerable accuracy, and great benefit and relief to vision. We may also, as will be seen, with advantage correct to some extent many cases of irregular corneal astigmatism.

We are now ready to consider the surface of the cornea with relation to its refractive points. From this another important classification for the good understanding and treatment of astigmatism is drawn. Thomas Young, who may be considered the real discoverer of astigmatism, found the maximum of curvature in the vertical meridian of the dioptric system. Since his time, it has been demonstrated, by means of the ophthalmometer, that this is also (Helmholtz, Donders) true of the cornea. It may be laid down then as a rule, to which, however, there are exceptions. It is from this rule that we deduce the classification of

1. Astigmatism with the rule.
2. Astigmatism against the rule.

When we say astigmatism with the rule, we mean where the greatest axis of curvature is, as Thomas Young so long ago proved it to be, in the vertical meridian or approximating this meridian. When it is in the horizontal meridian or approximating it, it is against the rule. When it is at an angle of 45°, it is neither with nor against the rule.

The cornea is an ellipsoid, and from its form astigmatism is produced in all human eyes. It only is to be determined how much, or rather how little, of corneal and regular astigmatism may be troublesome enough to be considered abnormal. As Donders says, it is established by the foregoing, not only that the cornea produces astigmatism, but that "even if the crystalline lens has an influence upon it, the direction given to it in general by the cornea preponderates." This is the reason that the ophthalmometer, while it can only measure the corneal astigmatism, is of such great value.[1]

Irregular astigmatism belongs largely to the lens, with *polyopia* of one eye. Donders proved this by examination of eyes without the lens (aphakia) when all the phenomena of irregular astigmatism are removed.

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[1] Donders, *loc. cit.*, p. 455.

Diagnosis.—The diagnosis of considerable degrees of astigmatism is a very simple matter. It may be determined by testing the distance at which fine vertical and horizontal lines are respectively seen. The great majority of eyes, as shown by Donders, see vertical lines farther than horizontal ones. The clock-dial test (John Green) will very quickly indicate if there be a high degree. With the aid of convex and concave glasses we may soon determine its axis, and pretty accurately its degree. But this is, of course, only a primitive and rude test applicable to those cases, where the regular astigmatism considerably exceeds that which obtains in all persons with a low degree of hypermetropia, those who by many writers are considered as emmetropic. Just how high a degree of astigmatism may be considered abnormal and under proper circumstances worthy of correction, has not been generally decided. Donders at first spoke of about $\frac{1}{40}$, about one diopter, as being worthy of consideration, but he afterward made his standard much higher and speaks of a correction of $\frac{1}{80}$, or 0.50 diopters, as being well worthy of correction. He insists upon the measurement of astigmatism by tests at the far point of vision, and he did not consider Knapp's statistics as of value, because he states they were taken from the near point.

The disturbances of vision caused by astigmatism of a high degree, are peculiar and considerable. Until our general knowledge of the defect, many persons having it were considered to be hopelessly defective in sight, as they were without cylindric glasses. Even to-day, in places remote from experts in the eye, cases are constantly found of people suffering from corneal astigmatism only, who have lived to middle life without seeing well, who are almost entirely, and in some cases entirely, relieved by the correction of astigmatism by means of cylindrical glasses. Astigmatism is in fact more frequent in the ordinary hypermetropic eye than it is in myopic eyes, and yet those who first discovered the defect in their own eyes, Thomas Young and Airy, had myopic astigmatism, and Young that very rare form, lenticular, unless there was some error in his observations, which has as yet remains undiscovered.

From the investigations of Javal and Schötz, and myself, I think we are justified in saying that an astigmatism, corneal

of course, of 0.75 *with the rule* is usually in need of correction, if any asthenopia occur, while even 25 D. *against the rule* may be productive of very annoying disturbance in using the eyes for the near point, and may require correction. It will be remembered that in astigmatism with the rule, or according to the rule, the vertical meridian of the eye is of the greatest curvature. A positive cylindrical glass placed with the axis at 90° will correct it, and in myopia a concave cylinder with the axis at 180°. It may be necessary to remind the student, that the glasses ground to correct hypermetropia are from a sphere, spherical glasses, and have the same refractive power in all meridians, while those for the correction of astigmatism are from a cylinder and have, therefore, one meridian that is a plane surface and consequently without refractive power.

THE DEGREE OF ASTIGMATISM LIKELY TO PRODUCE ASTHENOPIA.

For the purpose of determining what degree of corneal astigmatism would be likely to produce asthenopia, at my request, Dr. A. B. Deynard, one of my staff of assistant surgeons at the Manhattan Eye and Ear Hospital, examined one hundred eyes of persons not suffering from asthenopia, with reference to the existence of corneal astigmatism. The results of this examination confirm, I think, the opinions that astigmatism is a more important element in the production of asthenopia than hypermetropia, and that we may now enlarge Donders' statement, that hypermetropia was at the bottom of most cases of asthenopia, and say that *hypermetropic astigmatism, or hypermetropia, or both combined, are at the bottom of most cases of true asthenopia.*

The persons examined by Dr. Deynard had no asthenopia, never had suffered from it, and we should not on *a priori* grounds expect them to be asthenopic. They had a low degree of corneal astigmatism, and a low degree of hypermetropia. They were not myopic. They had normal eyes. Normal eyes are seldom asthenopic.

My tables confirm the rule laid down by Javal, that corneal astigmatism need not be corrected, unless it exceed 0.50 diopter, and they also indicate what we have long known, that

a considerable degree of hypermetropia may exist without asthenopia. In my judgment, we may with propriety and with great advantage to accuracy and consequent benefit to the patients, abandon all other methods for determining astigmatism, except in very rare cases, and trust entirely to the ophthalmometer. In the few exceptional cases, there remains paralysis of the ciliary muscle by atropia or scopolamine, and the tests with glasses. By its aid and a set of test-cards and correcting glasses, without a mydriatic, without retinoscopy, we may determine, in a vast majority of cases, whether or not corneal astigmatism exists, what its degree and axis are, and, moreover, prescribe glasses which will be entirely satisfactory.

The subtraction of half a diopter for the neutralizing action of the lens, will generally give, in *astigmatism with the rule*, the degree that remains for correction, and as Donders stated in 1864, in the English language, the total astigmatism of the dioptric system of the eye.[1]

In corneal astigmatism against the rule, the action of the lens does not (whatever it may be) practically lessen the astigmatism. It must then be fully or over-corrected in order to relieve the symptoms.

It required more than twelve months to secure a hundred subjects who should fulfil the indications for an examination. The subjects were obtained chiefly from the patients in the aural clinics and from the physicians attending the practice of the Manhattan Eye and Ear Hospital, and from the attending and home staff. It is hardly necessary to state that great care was taken to make the examinations accurate. They were very often repeated and subjected to an examination from another observer than Dr. Deynard, when he felt any doubt as to the fitness of the subject in the fulfilment of the conditions for examination, or as to the readings of the ophthalmometer. Nearly every one of the subjects had $\frac{20}{20}$ vision. Many had $\frac{20}{15}$. The examinations were made in a room uniformly lighted. This is a standard sufficiently exact for ordinary reference and work. From my point of view, when $\frac{20}{15}$ or $\frac{20}{20}$, or even $\frac{20}{20}$ —, is easily and fluently obtained it is sufficient vision to be pronounced normal. I do not

[1] New York Medical Record, Nov. 16th, 1893.

make investigations of asthenopia from the standpoint of the patient having ideal vision, or that which the most far-seeing eye can secure, but rather on the ability to use the eyes without fatigue for a proper period of time, this being coincident with $\frac{20}{20}$, or at least $\frac{20}{20}$ —.

The general table is first presented. Afterward it is classified in sub-tables, and an analysis made of its results. As these examinations were intended chiefly to estimate the corneal astigmatism, the examination of the axial refraction, so-called, was made by the ophthalmoscope, and in some instances by the use of convex glasses. If atropia had been used, or complete paralysis of accommodation had been secured by any means, undoubtedly even a large percentage of hypermetropia would have been found. With the examinations as made there were nine who had no hypermetropia. The corneal astigmatism was as follows:

A Table Showing the Corneal Astigmatism of 100 Persons, with Normal Vision $\frac{20}{20}$ or $\frac{20}{20}$—, and without Asthenopia.

No.	Age.	Sex.	Occupation.	Vision.	Refraction by Ophthalmoscope.	Javal.
1	25	M.	Physician.	20/15	2	25 90°
				20/15	2	25 90°
2	37	F.	Nurse.	20/30 24/20 w. 1.90°	2	2 90°
				20/30 20/20 w. 1.90	2	2 90
3	31	M.	Physician.	20/15	1	25 90°
				20/20—	1	25 90
4	13	M.	Student.	20/20—	1	50 90°
				20/20—	1	50 90°
5	12	F.	Student.	20/20—	1	1 90°
				20/20—	1	1 90°
6	26	M.	Waiter.	20/20—	1	1 90°
				20/20—	1	1 90°
7	25	F.	Dressmaker.	20/20—	1	1 90°
				20/20—	1	1 90°
8	23	F.	Seamstress.	20/20	2	75 90°
				20/20	2	75 90
9	40	F.	Dressmaker.	20/20	E.	50 90
				20/20	E.	50 90°
10	35	M.	Clerk.	20/20	1	1 90
				20/20	1	1 90°
11	34	M.	Physician.	20/15	1	Negative.
				20/15	1	25 90
12	18	F.	Dressmaker.	20/20	1	1 90°
				20/20	1	1 90
13	32	M.	Bricklayer.	20/20	1	1 90°
				20/30		
				20/20 w. 50 90	1	50 90°
14	22	M.	Clerk.	20/20	1	1 90°
				20/20	1	1 90°
15	23	M.	Porter.	20/20	1	25 90°
				20/20	1	25 90

TABLE SHOWING CORNEAL ASTIGMATISM OF 100 PERSONS—(*Continued*).

No.	Age.	Sex.	Occupation.	Vision.	Refraction by Ophthalmoscope.	Javal.
16	37	M.	Physician.	20/20	1	25 90
				20/20	1	25 90°
17	20	M.	Clerk.	20/20	1	25 90
				20/20	1	25 90
18	39	M.	Teamster.	20/20	2	50 90°
				20/20	2	50 90°
19	30	M.	Physician.	20/20—	1	Negative.
				20/20—	1	Negative.
20	32	M.	Sailor.	20/20	1	1 90
				20/20	1	1 90°
21	35	M.	Porter.	20/30	4	1 45
				20/30—	3	Negative.
22	26	M.	Gardener.	20/20	1	1 90
				20/20	1	1 90
23	23	F.	Physician.	20/20	2	50 90
				20/20	2	25 90°
24	....	F.	Seamstress.	20/40		
				20/30 20 75 90°	1	25 90°
				20/20	1	50 90
25	14	M.	Student.	20/20	3	1 90°
				20/20		
				20/20 20 50 90°	3	50 90°
26	33	F.	Stenographer.	20/20	E.	75 90°
				20/20	E.	75 90°
27	17	F.	Silk-picker.	20/40		
				20/30 20/20 w. 50 180	2	1 90°
					2	50 90°
28	26	F.	Housewife	20/20—	1	1 90
				20/20—	1	1 90°
29	26	M.	Janitor.	20/20	2	50 90°
				20/20	2	50 90°
30	16	M.	Student.	20/20	2	50 90
				20/40		
				20/30 w. 50 90	3	1.00 90°
31	40	F.	Housewife.	20/20	2	50 90°
				20/20	2	50 90°
32	30	M.	Clerk.	20/20 20 —50 90°	3	1.25 90°
				20/20 20 —50 90°	3	1.25 90°
33	18	M.	Student.	20/20	3	50 90°
				20/20—	2	1.00 90°
34	23	M.	Fireman.	20/20	E.	1 90
				20/20	E.	1 90
35	21	F.	Housewife.	20/20—	3	2 90°
				20/20—	3	2 90°
36	19	M.	Student.	20/20	1	50 90°
				20/20	1	50 90°
37	32	F.	Housewife.	20/20		
				20/20 20 25 cy. 90°	1	1 90°
				20/20		
				20/20 20 25 cy. 90°	1	1 90°
38	40	M.	Physician.	20/20—	E.	25 90°
				20/20—	E.	25 90°
39	29	M.	Mason.	20/20—	2	50 90
				20/20—	2	50 90°

TABLE SHOWING CORNEAL ASTIGMATISM OF 100 PERSONS—(*Continued*).

No.	Age.	Sex.	Occupation.	Vision.	Refraction by Ophthalmoscope.	Javal.
40	30	M.	Physician.	20/30, 20/20 w. 25 180°	1	50 180°
				20/20	1	50 180°
41	19	F.	Dressmaker.	20/20	2	25 90°
				20/20	2	25 90
42	20	F.	Clerk.	20/20	2	50 90°
				20/20	2	50 90°
43	28	M.	Physician.	20/20	E.	50 90°
				20/20	E.	Negative.
44	28	F.	Housewife.	20/20	1	1 90°
				20/20	1	1 90°
45	40	F.	Housewife.	20/20	1	50 90°
				20/20	1	50 90°
46	25	M.	Physician.	20/20	1	50 90°
				20/20	1	50 90°
47	21	F.	Teacher.	20/20	2	1 90°
				20/20	2	1 90°
48	28	F.	Housewife.	20/20	1	1.25 90°
				20/20	1	1.25 90°
49	21	F.	Waiter.	20/20	2	Negative.
				20/20	2	·25 90°
50	25	M.	Physician.	20/20 —	1	50 90°
				20/20 —	1	50 90°
51	21	F.	Housewife.	20/30 no glass.	2	1 90°
				20/20	2	50 90°
52	19	F.	Housewife.	20/20	2	1 90°
				20/20	2	1 90°
53	18	F.	Sewing.	20/20 —	1	Negative.
				20/20 —	1	50 90°
54	15	M.	Student.	20/20	2	1 90°
				20/20	2	1.25 90°
55	19	F.	Student.	20/15 —	1	Negative.
				20/15 —	1	Negative.
56	36	M.	Clergyman.	20/20	1	25 180°
				20/20	1	Negative.
57	23	F.	Housewife.	20/20	2	1 85°
				20/20	2	1 90°
58	23	F.	Housewife.	20/20	2	1 90°
				20/20	2	1 90°
59	40	M.	Clerk.	20/20	1	Negative.
				20/20	2	Negative.
60	16	F.	Student.	20/20	1	1 90°
				20/20	1	1 90°
61	17	F.	Clerk.	R. 20/30, 20/20 w. 1.90 cy.	2	2 90°
				L. 20/30, 20/20 w. 1.90 cy.	2	2 90°
62	22	F.	Dressmaker.	20/20	2	1 90°
				20/20	1	1 90°
63	25	M.	Clerk.	20/20	2	50 90°
				20/20	2	50 90°
64	18	M.	Clerk.	20/20	2	1 90°
				20/20	2	1 90°
65	14	F.	School.	20/20	3	3 105°
				20/20	3	3 90

TABLE SHOWING CORNEAL ASTIGMATISM OF 100 PERSONS—(*Continued*).

No.	Age.	Sex.	Occupation.	Vision.	Refraction by Opnthalmoscope.	Javal.
66	25	F.	Housewife.	20/20	1	Negative.
				20/20	1	Negative.
67	40	F.	Housewife.	20/20	1	25 90
				20/20	1	25 90
68	28	M.	Physician.	20/20	1	25 90
				20/20	1	25 90
69	30	M.	Physician.	20/20—	1	25 90
				20/20—	1	25 90°
70	15	F.	Clerk.	20/20	2	1 90
				20/20	2	1 90
71	21	F.	Housewife.	20/20	1	1 90°
				20/20	1	1 90
72	28	F.	Housewife.	20/20	2	25 180°
				20/20	2	25 180
73	19	F.	Housewife.	20/20	2	50 90
				20/20	2	1.60 90°
74	40	M.	Physician.	20/20	E.	50 90
				20/20	E.	25 90°
75	24	F.	Nurse.	20/20	2	50 90°
				20/20	2	50 90°
76	21	F.	Telegrapher.	20/20	2	50 90
				20/20	1	50 90
77	39	F.	Dressmaker.	20/20	1	50 90°
				20/20	1	50 90°
78	21	F.	Housekeeper.	20/20	1	50 90
				20/20	1	50 90°
79	32	F.	Housewife.	20/20	1	1 180°
				20/20	1	50 180
80	34	M.	Weaver.	20/20	2	25 90
				20/20—	2	25 90°
81	26	F.	Servant.	20/20	2	2 90
				20/20—	2	1.80 90°
82	25	F.	Dressmaker.	20/20—	1	1 90°
				20/20—	1	1 90°
83	11	M.	School.	20/20	2	25 90°
				20/20	2	25 90
84	25	M.	Clerk.	20/20	1	25 90°
				20/20	1	25 90°
85	22	M.	Driver.	20/20	1	1.25 90°
				20/20	1	1.25 90°
86	20	M.	Bartender.	20/20	2	50 90°
				20/20	2	50 90°
87	21	F.	Music teacher.	20/20	1	1 75°
				20/20	1	1 90°
88	27	M.	Clerk.	20/20—	2	50 90°
				20/20—	2	50 90
89	21	M.	Physician.	20/20	E.	Negative.
				20/20	E.	50 90
90	11	M.	School.	20/20	2	1 90
				20/20	2	1 90°
91	40	M.	Bookkeeper.	20/20	1	1 110
				20/20—	1	Negative.
92	40	M.	Car-driver.	R. 20/20	1	50 90
				L. 20/30	2	
				20/20 w. 1.90°	....	2 90

TABLE SHOWING CORNEAL ASTIGMATISM OF 100 PERSONS—(*Continued*).

No.	Age.	Sex.	Occupation.	Vision.	Refraction by Ophthalmoscope.	Javal.
93	40	M.	Physician.	$\frac{20}{20}$—	E.	25 90°
				$\frac{20}{20}$—	E.	50 90°
94	18	E.	Dressmaker.	$\frac{20}{20}$	2	1 90°
				$\frac{20}{20}$	2	1 90°
95	21	F.	Housewife.	R. ($\frac{20}{30}$		
				($\frac{20}{20}$ w. 50c. 105	2	1 105°
				L. ($\frac{20}{20}$	2	50 90°
96	24	M.	Student.	$\frac{20}{15}$	3	Negative.
				$\frac{20}{15}$	3	Negative.
97	25	M.	Physician.	$\frac{20}{20}$—	1	25 90°
				$\frac{20}{20}$—	1	50 90°
98	32	M.	Physician.	$\frac{20}{20}$	1	50 90°
				$\frac{20}{20}$	1	50 90°
99	25	F.	Singer.	$\frac{20}{15}$	E.	50 90°
				$\frac{20}{15}$	E.	50 90°
100	19	F.	Dressmaker.	$\frac{20}{20}$	2	50 90°
				$\frac{20}{20}$	2	25 90°

TABLE OF THOSE WHO WERE NOT FOUND TO BE HYPERMETROPIC.

No.	Age.	Sex.	Occupation.	Astigmatism.	
1	40	Female.	Dressmaker.	0.50	90°
2	33	Female.	Stenographer.	0.75	90°
3	23	Male.	Fireman.	1.00	90°
4	38	Male.	Physician.	25	90°
5	28	Male.	Physician.	R. E. 0.50	90°
				L. E.	None.
6	40	Male.	Physician.	R. E. 0.50	90°
				L. E. 0.25	90°
7	21	Male.	Physician.	R. E.	None.
				L. E. 0.50	90°
8	40	Male.	Physician.	R. E. 0.25	90°
				L. E. 0.50	90°
9	25	Female.	Singer.	0.50	90

It will be seen that not one of these who had no hypermetropia by the ophthalmoscope were without corneal astigmatism at least in one eye, but only two had sufficient corneal astigmatism (Cases II. and III. of the sub-table) to require correction. One had 1 diopter, the other ¾ of a diopter. There are, then, good reasons why those comprising this table should not be asthenopic. Without hypermetropia, except of a low grade at the very most, and in only one case with astigmatism of a degree to usually warrant correction, it would be a surprise if these subjects had asthenopia from local causes.

Of the one hundred, five had no astigmatism in either eye. All

of these were hyperopic, four to the degree of one diopter and one to that of three diopters.

WITH NO ASTIGMATISM.

No.	Age.	Sex.	Occupation.	Vision.	Hyperopia.
1	30	Male.	Physician.	$\frac{20}{20}$	1 D.
2	19	Female.	Student.	$\frac{20}{15}$	1 D.
3	40	Male.	Clerk.	$\frac{20}{20}$	R. 1 D. L. 2 D.
4	25	Female.	Housewife.	$\frac{20}{20}$	1 D.
5	24	Male.	Student.	$\frac{20}{15}$	3 D.

As far as this table indicates anything, it shows that hypermetropia of itself is not necessarily a cause of asthenopia. The one case of a moderately high degree, three diopters, was that of a student of nineteen years of age. She may yet have asthenopia if three diopters of hyperopia be sufficient to cause it. It should be remembered that all these subjects were questioned not only as to having asthenopia at the time of examination, but also as to whether they ever had had an attack of inability to continue to use their eyes in near work.

There were eight who had astigmatism in one eye only.

ASTIGMATISM IN ONE EYE ONLY.

No.	Age.	Sex.	Occupation.	Vision.	D.	Astigmatism.
1	34	M.	Physician.	$\frac{20}{15}$	1 D.	L. E. 0.25 90°
2	35	M.	Porter.	$\frac{20}{30}$	3 D.	R. E. 1.00 45°
3	28	M.	Physician.	$\frac{20}{20}$	None.	R. E. 0.50 90°
4	21	F.	Waitress.	$\frac{20}{20}$	2 D.	L. 0.25 90°
5	18	F.	Seamstress.	$\frac{20}{20}$	1 D.	L. E. 0.50 90°
6	36	M.	Clergyman.	$\frac{20}{30}$	1 D.	R. E. 0.25 180°
7	21	M.	Physician.	$\frac{20}{20}$	None.	L. E. 0.50 90°
8	40	M.	Bookkeeper.	$\frac{20}{20}$	1 D.	R. 1.00 110°

No. 2 in this case has the optical conditions to cause asthenopia. There is a considerable degree of hyperopia (3 D.) and astigmatism in one eye, of one diopter axis 45°. This subject, however, has an occupation not necessarily involving much use of the eyes upon near objects, and he may escape until he is presbyopic, when if he reads much he may require a correction of his astigmatism in one eye to be comfortable; but if he reads very little he may not need anything but spherical glasses.

Another of this table, No. 8, a bookkeeper, would be presumed to require correction of his refractive defect, for he has one diopter of hypermetropia added to a diopter of astigmatism, the latter in the

right eye, axis 110°. The remainder, however, I do not think would be expected, even under considerable use of the eyes, to have asthenopia.

Thirteen had less than half a diopter in both eyes, as follows:

Less than Half a Diopter of Astigmatism in Both Eyes.

No.	Age.	Sex.	Occupation.	Vision.	D.	Astigmatism.
1	25	Male.	Clerk.	20/20	1 D.	0.25 90°
2	11	Male.	Scholar.	20/20	2 D.	0.25 90°
3	34	Male.	Weaver.	20/20	2 D.	0.25 90
4	40	Female.	Housewife.	20/20	1 D.	0.25 90
5	28	Male.	Physician.	20/20	1 D.	0.25 90°
6	30	Male.	Physician.	20/20	1 D.	0.25 90°
7	28	Female.	Housewife.	20/20	2 D.	0.25 90°
8	40	Male.	Physician.	20/20	None.	0.25 90°
9	23	Male.	Porter.	20/20	1 D.	0.25 90°
10	37	Male.	Physician.	20/20	1 D.	0.25 90°
11	20	Male.	Clerk.	20/20	1 D.	0.25 90°
12	25	Male.	Physician.	20/15	2 D.	0.25 90°
13	31	Male.	Physician.	20/15	1 D.	0.25 90°

Not one of this table can be said to be liable to asthenopia from refractive error, unless two diopters of hyperopia, which four of the subjects had, are thought to constitute such a liability.

Twenty had astigmatism of just one-half a diopter in both eyes.

Astigmatism of One-half a Diopter in Each Eye.

No.	Age.	Sex.	Occupation.	Vision.	Hypermetropia.
1	25	Female.	Singer.	20/15	None.
2	32	Male.	Physician.	20/02	1 D.
3	21	Female.	Telegrapher.	20/20	R. 2 D.
					L. 1 D.
4	39	Female.	Dressmaker.	20/20	1 D.
5	20	Male.	Bartender.	20/20	2 D.
6	27	Male.	Clerk.	20/20	2 D.
7	25	Male.	Clerk.	20/20	2 D.
8	24	Female.	Nurse.	20/20	2 D.
9	40	Female.	Housewife.	20/20	1 D.
10	25	Male.	Physician.	20/20	1 D.
11	25	Male.	Physician.	20/20	1 D.
12	40	Female.	Housewife.	20/20	2 D.
13	19	Male.	Student.	20/20	1 D.
14	29	Male.	Mason.	20/20	2 D.
15	30	Male.	Physician.	20/30	
				R. 20/20 w. 25 180	180°
				L. 20/20	1 D. 180
16	20	Female.	Clerk.	20/20	2 D.
17	39	Male.	Teamster.	20/20	2 D.
18	26	Male.	Janitor.	20/20	2 D.
19	13	Male.	Student.	20/20—	1 D.
20	40	Female.	Dressmaker.	20/20	None.

In only one of these, No. 15, a physician, was the axis 180° (astigmatism against the rule). Here we might expect asthenopia, or at least if it occurs, we certainly would explain it by the existence of half a diopter of astigmatism against the rule. In none of the other of this table of twenty cases should we expect asthenopia. The astigmatism equalled 0.75 of a diopter, as follows, in two subjects:

No.	Age.	Sex.	Occupation	Vision.	Hypermetropia	Axis of As.
1	23	Female.	Seamstress.	20/20	2 D.	90°
2	33	Female.	Stenographer.	20/20	None.	90°

Three-fourths of a diopter (axis 90°) is the first degree of corneal astigmatism that I am in the habit of correcting. One of these patients it will be noted had two diopters of hypermetropia.

Twenty-five, or one-fourth of the whole number, had 1 D. of astigmatism in each eye, as follows:

No.	Age.	Sex.	Occupation.	Vision.	Hypermetropia.
1	12	F.	Student.	20/20—	1 D.
2	26	M.	Waiter.	20/20—	1 D.
3	25	F.	Dressmaker.	20/20—	1 D.
4	18	F.	Dressmaker.	20/20	1 D.
5	22	M.	Clerk.	20/20	1 D.
6	32	M.	Sailor.	20/20	1 D.
7	26	M.	Gardener.	20/20	1 D.
8	26	F.	Housewife.	20/20—	1 D.
9	23	M.	Fireman.	20/20	None.
10	32	F.	Housewife.	20/20	1 D.
11	28	F.	Housewife.	20/20	1 D.
12	19	F.	Housewife.	20/20	2 D.
13	23	F.	Housewife.	20/20	2 D., R. E. 85°
14	23	F.	Housewife.	20/20	2 D.
15	16	F.	Student.	20/20	1 D.
16	22	F.	Dressmaker.	20/20	R. E. 2 D.
					L. E. 1 D.
17	18	M.	Clerk.	20/20	2 D.
18	15	F.	Clerk.	20/20	1 D.
19	21	F.	Housewife.	20/20	1 D.
20	25	F.	Dressmaker.	20/20	1 D.
21	24	F.	Music teacher.	20/20	1 D., R. E. 75°
					L. E. 90°
22	11	M.	Student.	20/20	2 D.
23	18	F.	Dressmaker.	20/20	1 D.
24	35	M.	Clerk.	20/20	1 D.
25	21	F.	Teacher.	20/20	2 D.

In this table the symmetry of the conditions is interesting. The axis was 90° in all of the cases but two. In one eye of one of these, it was 85°. In one of the others it was 75°. The hypermetropia also

was one diopter in two-thirds of the subjects. In one case there was none. In seven cases it was two diopters.

In four of the subjects the corneal astigmatism was more that one diopter in both eyes, as follows:

No.	Age.	Sex	Occupation.	Vision.	H.	Axis.
1	30	Male.	Clerk.	20/20	3 D.	1.25
2	28	Female.	Housewife.	20/21	1 D.	1.25
3	14	Female.	Student.	20/20	3 D.	3.00 105° 90°
4	22	Male.	Driver.	20/20	1 D.	1.25

No doubt the third one of the table, who was one of fourteen other students examined, if she remains a student or in any occupation requiring close use of her eyes, will require glasses, for she has three diopters of astigmatism, added to three diopters of hyperopia. The others may easily escape the need of correction of the astigmatism, until presbyopia comes upon them.

In twenty-six of the subjects the eyes of the same subject differed in the degree of astigmatism as follows:

No.	Age.	Sex.	Occupation.	Vision.	H.	Axis.
1	34	Male.	Physician.	20/15	1 D.	R. None. L. 0.25
2	32	Male.	Bricklayer.	20/20 20/30	1 D.	R. 1 D. L. 1 50
3	35	Male.	Porter.	20/30 L. 20/30	4 D.	R. 1 D. 45° L. None.
4	23	Female.	Porter.	20/20	2 D.	R. 0.50 L. 0.25
5	......	Female.	Seamstress.	20/40 L. 20/20	1 D.	R. 1.25 L. 0.50
6	24	Male.	Student.	20/20	3 D., 1 D.	1.25
7	17	Female.	Silk-picker.	20/20 L. 20/30	2 D.	R. 1.00 L. 0.50
8	16	Male.	Student.	20/20 L. 20/40	2 D. 3 D.	R. 0.50 L. 1 D.
9	18	Male.	Student.	20/20	3 D.	R. 0.50 L. 1 D.
10	19	Female.	Dressmaker.	20/20	2 D.	R. 0.25 L. 0.50
11	......	Male.	Physician.	20/20	None.	0 50 None.
12	21	Female.	Waitress.	20/20	2 D.	R. None. L. 0.25
13	21	Female.	Housewife.	20/20 20/30	2 D.	R. 1 D. L. 0.50
14	18	Female.	Seamstress.	20/20	1 D.	R. None. L. 0.50
15	15	Male.	Student.	20/20	2 D.	R. 1.00 L. 1.25

No.	Age.	Sex.	Occupation.	Vision.	H.	Axis.
16	36	Male.	Clergyman.	$\frac{20}{20}$	1 D.	R. 0.25 180° L. None.
17	19	Female.	Housewife.	$\frac{20}{20}$	2 D.	R. 0.50 L. 1 D.
18	40	Male.	Physician.	$\frac{20}{20}$	None.	R. 0.50 L. 0.25
19	32	Female.	Housewife.	$\frac{20}{20}$	1 D.	R. 1.00 180° L. 0.50 180
20	26	Female.	Servant.	$\frac{20}{20}$ $\frac{20}{20}$	2 D.	R. 2.00 L. 1.50
21	21	Male.	Physician.	$\frac{20}{20}$	2 D.	R. None. L. 0.50
22	40	Male.	Bookkeeper.	$\frac{20}{20}$	1 D.	R. 1.00 110 L. None.
23	40	Male.	Physician.	$\frac{20}{20}$	None.	R. 0.25 L. 0.50
24	21	Female.	Housewife.	$\frac{20}{30}$ $\frac{20}{20}$	2 D.	R. 1.00 105° L. 0.50 90°
25	25	Male.	Physician.	$\frac{20}{20}$	1 D.	R. 0.25 L. 0.50
26	19	Female.	Dressmaker.	$\frac{20}{20}$	2 D.	R 0.50 L. 0.25

The analysis of this table shows that eight were under twenty years of age, so that their danger from asthenopia is by no means past. The axis of astigmatism was 90° except in four cases. In one it was against the rule on both sides, or axis 180°.

It is seen at a glance that thirteen of the one hundred, namely, the two waiters, the bricklayer, the two porters, the gardener, the janitor, the fireman, the mason, the bartender, the car-driver, the sailor and teamster, had occupations that did not necessarily or probably involve any use of the eyes on fine or near objects. Undoubtedly such subjects have immunity from asthenopia, as compared with persons like the others of the total number, who must of necessity use their accommodative power very considerably, and in the case of seamstresses and dressmakers generally beyond proper limits; but it never should be forgotten that sound eyes, like other sound organs, are the better for use.

I should have much preferred to make these examinations only upon persons of the age of at least twenty-five years. The school-children in the list are not so good observers as to the existence of asthenopia, nor can they be said to be beyond the danger of it, until they have come to years when study, seriously and for several continuous hours, is habitual. But it is very difficult to secure even the class I have found with closer discrimination than Dr. Deynard has made. We have therefore made this presentation as a fair beginning only of a line of investigation which promises considerable addition

to our knowledge of the normal refraction of the eye. This table adds to the already overwhelming evidence that emmetropia is an ideal condition. It is doubtful if the use of atropia would have left one case of the general table that was neither hypermetropic in the axis of the eye or in the cornea. Negatively, the fact that the larger proportion of these had not the condition, that is to say, a considerable degree of astigmatism, that would lead us to expect asthenopia, were it uncorrected, while nearly all had hypermetropia, and of a decided degree, leads us to believe that hypermetropia is not a powerful factor in producing asthenopia, and that Donders' teaching remains true, that one to two diopters are readily overcome in youth.

I consider in analzying the table of one hundred that eleven had optical conditions that would generally be considered sufficient to account for asthenopia did it occur.

OCCUPATIONS.

Physicians	18	Teacher	1
Students	13	Singer	1
Dressmakers or Seamstresses	12	Weaver	1
Clerks	12	Bookkeeper	1
Stenographer	1	Clergyman	1
Silk-picker	1		—
Telegrapher	1	Total	64
Music-teacher	1		

The above table may be said to comprise those who have asthenopic occupations.

NON-ASTHENOPIC OCCUPATIONS.

Nurses	2	Fireman	1
Waiters	2	Mason	1
Bricklayer	1	Bartender	1
Porters	2	Car-driver	1
Teamsters	2	Servant	1
Sailor	1		—
Gardener	1	Total	36
Janitor	1		

Donders is sometimes erroneously quoted as saying that $\frac{1}{40}$—about a diopter—of astigmatism may be considered normal, but he says exactly the reverse of this, for example: "If it (corneal astigmatism) amount to $\frac{1}{40}$ or more, it must be considered as abnormal." Then again he is more emphatic (on page 512): "Boundaries between normal and abnormal astigmatism do not exist when it attains the degree of $\frac{1}{40}$ (1 diopter). I have called it abnormal because the disturbance of vision is of that nature that cylindrical glasses are desirable for its improvement, but otherwise it is evident that the limit I have fixed upon is rather arbitrary. With much slighter degrees the acuteness of vision is no longer perfect."

Donders then goes on to show that an astigmatism in his own eyes of about $\frac{1}{100}$ was capable of being improved by cylindrical glasses. He criticises Knapp's standard of normal astigmatism as being too high. He also says that of forty to fifty eyes one at least is disturbed in its functions by astigmatism. With his exact knowledge of the frequency, the axis of greatest curvature, the degree of what constitutes an abnormal astigmatism, Donders marked out the road on which many of us are now travelling; that is to say, that astigmatism, and not hyperopia, is the dominant cause of asthenopia. Important as is the axial length of the eyeball in one respect, the acuity of vision, in the production of asthenopia, the corneal astigmatism is more important. I do not claim that this is Donders' teaching. He did not know of the frequency of astigmatism of a considerable degree. He could not then teach this. It was his idea that hypermetropia was at the bottom of most asthenopia; but I do claim that this doctrine, with our increased facility in determining the degree of astigmatism, is legitimately deduced from the principles that he laid down in discussing astigmatism.[1]

Donders is very clear on the subject of the lessening of the corneal astigmatism by the lens. He thinks that occasionally the lens may increase the corneal astigmatism, but commonly[2] it diminishes it. He says that the lens may take part in astigmatism in two ways "by the form of curvature, and by an oblique position." Those who lightly estimate the ophthalmometer as a means of determining the degree and axis of astigmatism are constantly speaking of this action of the lens, as if it were something that cannot be estimated, and which destroys the value of the readings of the Javal and Schiotz instrument. The measurement of thousands of eyes by the ophthalmometer in the hands of Javal and his followers has demonstrated the truth of Donders' statement that the lens commonly lessens corneal astigmatism—and this is a recent observation—by about one-half a diopter when the axis is 90°, while none at all when the axis is 180° in hypermetropic eyes, and 90° in myopic.[3]

I am hardly able to comprehend the state of mind of a writer

[1] In a paper upon the asthenopia of astigmatic individuals, Dr. George T. Bull, of Paris, formerly of New York, read before the French Ophthalmological Society, states his belief that asthenopia is most frequent in astigmatism direct (according to the rule), and in mixed astigmatism. He classified astigmatism as direct, inverse, oblique, and mixed.—Comptes Rendus de la Société Française d'Ophthalmologie.

[2] *Loc. cit.*, p. 131.

[3] The preceding is an extract from my paper, in the Medical Record, Nov. 26th, 1892.

upon ophthalmology, who objects to the ophthalmometer because it is rather expensive. "Javal's optometer, although affording a simple and trustworthy means of calculating the amount of astigmatism, has the disadvantage of being expensive."[1] This is, indeed, true, since it costs about seventy-five dollars, but a case of lenses is also expensive, and the instruments for operating upon the eye are expensive. If the ophthalmometer is as important an instrument as the present writer believes it to be, even if it cost tenfold what it now does, it would certainly be indispensable in the practice of ophthalmology.

[1] Beny: "Diseases of the Eye," American edition, Philadelphia, 1893.

CHAPTER XXX.

ASTIGMATISM (*Continued*).

Diagnosis.—The Importance of the Ophthalmometer.—The Various Tests with Dials.—Tests with Ordinary Letters Sufficient.—Retinoscopy and the Ophthalmometer.—The Increase of Corneal Astigmatism.—Loring's Test of the Existence of Astigmatism.—Consequences of Uncorrected Astigmatism. —The Degree of Hypermetropia to be Left Uncorrected.—More Attention to Asthenopia in our Country than in Others.—Muscular Asthenopia.—Dependent Chiefly on Astigmatism.—Traceable to Weakened Constitutional Conditions.—Illustrative Cases.—Nomenclature.—Statistics, showing Errors of Refraction to be the Rule in the Human Race.—How Much can be Done with Want of Equilibrium of Ocular Muscles.—Sir William Rowan Hamilton.—Study of the Causation of Disease.—Cases showing that the Correction of Astigmatism Relieved the Asthenopia.—The Over-Estimation of the Value of Glas es.—Dependence of Migraine upon Astigmatism.—Deplorable Results from Long-Continued Efforts to Restore Muscular Balance of the Eyes.—Double Vision.

THERE are many refraction cases where we could accomplish more for our patients than we do, did they have the requisite patience to adapt themselves to what, for a few days, may be rather trying conditions. Such a case is one I am treating while these pages are passing through the press.

A lady of 57 years of age, very well preserved for her years, has myopic astigmatism in the left eye, amounting to 3 D. *against the rule*. With that eye she is still able to read without a glass, but she has considerable asthenopia. In the fellow-eye she has hypermetropic astigmatism of $2\frac{1}{2}$ D., also *against the rule*. With this eye she cannot read, but she has tolerably good vision at a distance without a glass, that is to say, $\frac{20}{50}$. I can adjust a glass to the left eye, that is, a convex cylindrical, with which she can read from seven to twelve inches, while in the other eye, I can bring the vision up to $\frac{20}{30}$ with a spherical and cylindrical glass combined. Although she complains bitterly of asthenopia, she is not willing to make a fair trial of the glass for reading, and also the glass for the distance, because, as she states, immediately after the trial: "Why, I can read without a glass with that eye, and I can see pretty well at a distance

with the other eye without one." I am persuaded that with a little trial she would be able to use both eyes, but she has become accustomed to her sight as it is, and, although she seeks advice, she has not the courage to take it.

DIAGNOSIS.

For those who have no ophthalmometer, the diagnosis must still, if exact, be made by means of a mydriatic. I insisted upon the importance of using atropia before the ophthalmometer was perfected, in various papers, which I may claim contributed somewhat toward the general adoption of the method in this country. I have not changed my opinion that a mydriatic, in the absence of a practical instrument for measuring the cornea, is essential, but I have entirely abandoned it since I had a good knowledge and experience of the usefulness of the method I now adopt. It is also practised by my staff in the Manhattan Ear and Eye Hospital. The method of paralysis of the accommodation, by means of a mydriatic, is a certain one, and will furnish excellent results in fitting glasses, but it is extremely irksome and trying to the patient, and attended by a slight degree of danger to the general health. The use of homatropine is thought by many to be equally efficient, and not so troublesome to the patient, but, granting all this, it is much inferior to the method with the ophthalmometer.

In persons of forty years or over, a diagnosis of astigmatism may be made, and its correction accomplished by the aid of the test-types and glasses alone. I never practised nor have I recommended any use of atropia, or any other mydriatic, for the determination of the refraction, in persons of this time of life. I have always deplored the unnecessary use of such a trying agent in those cases. The accommodation is sufficiently at rest if, when the age of forty is passed, vision is adjusted for infinite distance, without the use of any paralyzing agent. I cannot too strongly argue against the use of a mydriatic in such cases as unnecessary, although advocated by certain writers, who have a high idea of the influence of the refraction of the eye, upon certain neuroses such as chorea and epilepsy.

In the earlier days of the study of astigmatism, great stress was laid by all experts, upon the use of the various tests with

dials (Green), letters made up of vertical and horizontal stripes (Pray). They were most instructive and useful in the early days, and added much to the facility of studying what was then a newly discovered science, but I had for years found that a good set of test-types answered all the purposes of the tests with vertical and horizontal stripes, as did other oculists. Still authorities of deservedly high repute use them, but I urge my readers to give them up, or not to begin with them, as being entirely unnecessary. Our work is greatly simplified by omitting to use them. When a scientific work becomes thoroughly understood, it is always made simpler.

The reason that the test with ordinary letters is sufficient is the following. All letters are made up of vertical and horizontal lines, and a patient with astigmatism of any considerable degree is soon found to stumble over certain of them, while he pronounces others easily. He will be apt to miscall the letters which are made up predominantly of vertical or horizontal stripes, according to his astigmatism. I am, therefore, in the habit of noting, after examination, if the patient read fluently, calling all letters equally well, or if he miscalled. If the latter occurs, I regard it as indicative of the existence of astigmatism.

Consequently I taught my pupils, that it is a circumstance indicating astigmatism when a patient is able to read $\frac{20}{20}$ or $\frac{20}{30}$ after a fashion, but who hesitates and finally miscalls certain letters.

EXAMINATION.

It is well to be as objective as possible in all our examinations of the body—to rely as little as possible on the subjective ideas of the patient. A test of the visual power, however carefully conducted, is a subjective observation, while that with the ophthalmometer and the ophthalmoscope may be considered objective.

With a little practice with the ophthalmometer, retinoscopy also becomes of very little value. Loring never considered it of any importance, as I have shown in an earlier chapter. Much and complicated apparatus is always an index of impracticable knowledge. Retinoscopy consumes much time, it is a more

subjective method than that of measuring the curvature of the cornea, that is to say, it leaves considerable to the judgment of the observer, as to the number of the glass that corrects the error, and is only of certain value when the eye is under the influence of a mydriatic. This latter is just what the use of the ophthalmometer avoids.

I can hardly sufficiently condemn, as illogical and useless, the plan of using the ophthalmometer, and then verifying its readings by the use of atropia and retinoscopy. This is as if a mariner, after having made a good observation with the sextant, declined to record his latitude until he had verified it by dead reckoning. Even the use of test-glasses in many cases, of which an example is here given, as a type of a large number, may be dispensed with, if we have satisfied ourselves by a careful ophthalmoscopic examination that no lesion exists in the fundus, lens, or vitreous, and the test-cards show $\frac{20}{20}$ or more to express the distant vision.

If a young patient complains of asthenopia, and the vision is $\frac{20}{20}$ or $\frac{20}{15}$, as is often the case, we may immediately examine such a person with the ophthalmometer. If we find that there is corneal astigmatism, with the rule, of one diopter, we may safely prescribe a glass of 0.50 D., axis 90°, without any testing of the eyes. If the vision be as has just been mentioned, and there be astigmatism of $1\frac{1}{2}$ diopters, with the rule, we may prescribe a glass of 0.75, without subjective testing with glasses and cards. A young person with normal distant vision, will very often accept concave glasses in preference to convex, and he will probably not know the difference between the distant vision, with a glass of half a diopter, axis 90°, or with the same glass, axis 180°.

Subjective examination by test-cards, has been carried altogether to too great an extent by practitioners. Patients soon contradict themselves, for the simple reason that there is so little difference in the perceptive power with weak convex or concave glasses, that very few people can be relied upon to give correct answers. But if the ophthalmometric readings are positive, the practitioner will save much time, and be more correct in his prescriptions, if he will rely upon them alone.

The author has been subjected to some criticism on account

of his so-called exalted ideas of this exclusive value of the ophthalmometer. In answer to this, I may reply that I do not attach any more value to its markings than did Donders, with the original instrument of Helmholtz, and he placed it next to the ophthalmoscope in importance to ophthalmology. In addition to the great scientific revelations of one of the fathers of ophthalmology, we in our time have been able by the aid of the practical instrument, on lines laid down by Donders, to largely expand the domains of exact knowledge in a science that after the invention of the ophthalmoscope, easily held the first rank for accuracy of investigation. The student of ophthalmology who will patiently learn to use Helmholtz's second discovery, and who is able to make intelligent deductions from it, will find his work much more easy, much more pleasant, and much more exact, than it was when we had no such means for the diagnosis of corneal astigmatism. He will not be at all surprised at the enthusiasm, that exists among those who have been entirely released from the subjective and tiresome methods of the use of mydriatics and the practice of retinoscopy. The diagnosis of astigmatism by means of the ophthalmoscope, although it may be made, becomes also of no importance, except in cases of lenticular astigmatism, when of course the ophthalmometer will give no sign.

It is usually assumed, and, I believe, with correctness, that corneal astigmatism does not change materially as life goes on. Especially is this true of hyperopic astigmatism, but there are authentic cases on record which indicate that, in a certain proportion, even hypermetropic astigmatism advances, that is to say, the curvature of the cornea changes and without producing conical cornea.

As observations with the ophthalmometer continue to be made, I have no doubt we shall be able to settle this question of the frequency of the increase of corneal astigmatism.

On January 26th, 1889, I saw a girl of seventeen, who was suffering from asthenopia. Her eyes were put under the influence of atropia, and she was found to have a total astigmatism in the right eye of 0.75 D. at 90° and in the left 0.25 D. at 90°. Nearly two years afterward she was examined by the ophthalmometer, and was found

to have $1\frac{3}{4}$ of a diopter of astigmatism with the right eye, and $1\frac{1}{4}$ in the left, and accepted 1 D. in the right and $\frac{3}{4}$ D. in the left.

I do not adduce this case as a positive one of increase of corneal astigmatism, but it certainly may be one.

Dr. Theobald[1] reports three cases in which it was supposed that corneal astigmatism had increased. In his first case, atropine was used in the first examination, and after three years the astigmatism had increased from $\frac{1}{20}$ in each eye, to $\frac{1}{13}$. The second case was examined without atropia in the beginning, and I do not think it can, therefore, be considered in this category, because it was never positively known what the corneal astigmatism was at the first examination. This is also true of Theobald's third case.

Dr. George J. Bull, of Paris, also reports a similar case. It is that of a child, a patient of Javal's, who had convergent strabismus of the left eye. Dr. Bull states that in January, 1887, he examined the two eyes with the ophthalmometer, and he found astigmatism of 0.75 D. of the two eyes, the meridian of greatest refraction being exactly vertical, and he noted the fact that in the right eye the astigmatism was not more than 0.50 D. After the use of atropine, Javal found hypermetropia of 2.50 D., the only evidence of astigmatism of the right eye, being given by the ophthalmometer. One month after the condition was the same, and in June of the same year there was no subjective astigmatism. In November, 1887, being examined anew with the ophthalmometer, Dr. Bull noted an astigmatism of three-fourths of the two sides. In July, 1889, the child having often complained that she could not see well with the right eye, Dr. Bull measured it anew, and found in the left cornea an astigmatism of 1.25 and on the right 2.75. He was very much surprised at this augmentation, $\frac{1}{2}$ D. of the left eye, and 2 D. of the right. He examined the refraction with glasses, without atropine, and he found the left eye emmetropic and the right with an astigmatism of 2 D. The cylindrical glass produced great improvement in the vision for far and for near. Javal examined the patient independently, and with the same result as Dr. Bull. The child and its mother stated positively, that only for a few months had they perceived any change in the right eye. As Dr. Bull says, it is not possible that he should have made, after three examinations in succes-

[1] Transactions of the American Ophthalmological Society, 1885, p. 29.

sion, a mistake of 2 D. with the ophthalmometer, and that Javal should have made the same mistake, and that under atropine such a degree of astigmatism should have escaped attention. He is, therefore, bound to believe that there was a great increase of the astigmatism, very difficult to explain with our present knowledge of the etiology of astigmatism.

It does not seem to me that these cases are as difficult of explanation, in the light of Dr. Emerson's case quoted in discussing conical cornea, as Dr. Bull intimates. The increase in the astigmatism depends on a stretching, thinning of the cornea, and also means an approximation toward conical cornea.

Loring found in the observation of the light streak, the best test by the ophthalmoscope of the existence of astigmatism. The streak loses its brilliancy and its lateral borders lose their sharpness of definition; a vessel there, especially a small one, becomes out of focus even to a very slight degree. He claimed that as low a degree of astigmatism as 0.75 D. could be detected by this test, if the observed and observing eye were both completely relaxed. If the eye examined were myopic, Loring[1] claimed that as low as 0.50 could be detected.

CONSEQUENCES OF UNCORRECTED ASTIGMATISM.

Astigmatism of a high degree usually causes considerable impairment of vision. But if the astigmatism be simply hypermetropic, according to the rule, this is not necessarily the case. Every ophthalmologist of large experience will recall cases, where the vision has remained $\frac{20}{20}$ even up to presbyopia, in uncorrected astigmatism of as much as three diopters, but this is unusual. Especially if the astigmatism be removed from the vertical meridian in the hyperopic form, and from the horizontal in the myopic, will this be the case. It has already been observed that in places where expert advice in ophthalmoscopy is not to be obtained, cases of astigmatism are often seen which may be completely corrected by glasses, and which have been supposed to be due to organic and incurable disease of the eye.

Astigmatism against the rule, and mixed astigmatism, the

[1] "Text-Book of Ophthalmoscopy," vol. i., p. 118.

latter especially, usually impair the sight very much. The correction of the latter form, under the most favorable conditions, will require the most care. It is not always easy to determine how much of the corneal error is myopic and how much hypermetropic, because the ophthalmometer can only determine the degree. The ophthalmoscope should be critically used, and if good vision is not secured with the trial glasses, in two or three sittings, a mydriatic must be employed. With a little patience, and careful ophthalmoscopy, this will generally be avoided.

The chief result of uncorrected astigmatism of a low degree, especially of hyperopic astigmatism, is to produce asthenopia, as has been several times stated in this volume. Donders believed that hypermetropia was at the bottom of most cases of asthenopia and although he recognizes the asthenopia dependent upon astigmatism, he chiefly lays stress upon the impairment of vision produced by this error of refraction. He certainly did not give it as high a place in the production of asthenopia as seems to be proper in the light of recent investigations. From my experience, I think that uncorrected hyperopic astigmatism is the chief source of asthenopia. So important a factor is it, that we need not in young persons, unless the axial refraction be highly hypermetropic, correct this at all, but be content with correcting the astigmatism for near work only. This is when the vision without glasses is $\frac{20}{20}$ or $\frac{20}{30}$. Just how much hypermetropia we may leave uncorrected I can hardly say any more exactly than to indicate from 2 to 3 diopters as the limit. When much higher than this, it is apt, except in young children, or persons under fifteen years of age, to produce amblyopia, and it should always be corrected when this is the case.

Without doubt there is much more attention given to asthenopia in our country than in any others. Whether there is actually a wider prevalence of this symptom among us than in England, France, and Germany, I cannot say, but there is certainly more attention to errors and so-called errors of refraction, and so-called muscular asthenopia, with us than among the people of the old world. It was long ago remarked by a German authority, in the early days of ophthalmology, and just after the general knowledge of astigmatism and hypermetropia, that the American oculists soon became very expert in the adjustment

of glasses, in accordance with the principles that had been then recently promulgated for the first time.

A reference to the table in Chapter IV., made up from various hospitals and infirmaries in the United States, shows what a preponderance there is of cases requiring, or seeming to require, glasses, among the patients even of the poorer classes who attend the clinics. In private practice the proportion is still larger. The persons who come to my clinics at the Hospital for glasses are largely dress-makers, persons engaged in millinery, seamstresses, and the like among women, and school children of both sexes; with printers, salesmen, bookkeepers among men. The table in Chapter XXIX. illustrates this.

Formerly I corrected the astigmatism and a part of the hypermetropia, leaving the more hypermetropia uncorrected the younger the subject, but I now adopt the method mentioned above, of correcting the corneal astigmatism with the rule, less one-half a diopter for the corrective power exerted by the lens, and all of the astigmatism against the rule. Moreover, in some cases where the ophthalmometer marking, is plainly, no astigmatism, I occasionally find advantage in a cylinder of one diopter or one-half a diopter, with the axis at 180° if the patient be hypermetropic, and at 90° if the patient be myopic, but this is rarely the case. It may be, that an error of mistaking 0.25 against the rule for no astigmatism, has been made in these exceptional cases.

It is sometimes extremely difficult in one examination, to say that not even 0.25 D. exists.

MUSCULAR ASTHENOPIA.

Although I have already discussed this subject at some length in a preceding chapter, I am obliged to return to it here, as being of importance, in my judgment, and requiring more full illustration.

Muscular asthenopia has played a great part in the diagnosis of refractive cases in our country. One of the believers in great and widespread influence of the eye upon neuroses, abandoned the idea that hypermetropia was the cause of epilepsy

and chorea, "more than all other causes combined," to urge that uncorrected insufficiencies of the external muscles was the real cause. This author[1] has had many followers. Most of them have not gone so far as he, but there has been and continues to be an extensive practice of tenotomy and use of prisms to correct defects, which in my opinion, after very careful examinations continued for years, depend upon errors of refraction, if disturbing, and which may exist and do exist in persons who have no asthenopia, and no neuroses, such as chorea and epilepsy. I formerly practised tenotomy to a limited degree for latent insufficiencies, and prescribed prisms very frequently. The thorough use of atropia, soon in great part convinced me of the complete dependence of muscular asthenopia upon errors of refraction, chiefly upon astigmatism, and I gradually ceased almost entirely to prescribe prisms, having found them sometimes beneficial but almost always makeshifts, and poor substitutes for cylindric glasses. When I became familiar with the use of the ophthalmometer in 1888, I once for all abandoned the idea of relieving muscular asthenopia, except by correction of an error of refraction, and I advised, as I do now, that the term be given up as having no rightful place as generally used in ophthalmology. If the student will carefully correct the errors of refraction, he will have no need for tenotomies except for strabismus, nor for prisms except for paresis or paralysis of the external muscles.

The belief in any morbid constitutional condition of more than a passing nature, being dependent upon an error of refraction or a latent insufficiency of an external muscle of the eye,[2] I could never accept, and my views upon this subject were placed before the profession at a very early date.[3] Time and added experience have deepened my conviction that the cures accomplished by tenotomies and prisms in such cases, were mainly suggestive and many of them were illusory, occurring in neurotics who came into the world with an abnormal nervous system, and in whom symptoms are as variable as the changing of the wind.

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[1] G. T. Stevens: "Functional Nervous Diseases," D. Appleton & Co., 1887.

[2] "The Relation of Errors of Refraction and Insufficiency of the Ocular Muscles to Functional Diseases of the Nervous System." Medical Record, April 19th, 1890.

[3] Medical Record, October 9th, 1880.

Such persons will always have recourse to medical advice to alleviate their symptoms, but they are better under the care of wise general physicians than in the hands of oculists. Without doubt, asthenopia may occasionally cause morbid general sensations, and even great depression of spirits, coming to be almost melancholia, but in such cases the origin of the trouble is easily traced to true asthenopia. There is much asthenopia with us in the United States, directly traceable to weakened constitutional conditions, anæmia, nervous conditions after typhoid fever, measles, and the like, and which may or may not be associated with errors of refraction worthy of correction. The following cases illustrate how constitutional conditions, especially malaria, may be mistakenly supposed to be dependent upon an ocular defect.

A rather remarkable case was that of a lady of middle life who had been very well the most of her days, until she spent a summer in a malarial district near New York. On her return, she had many head symptoms. She was found to have myopic astigmatism, which had never before given her any inconvenience. The proper glasses were adjusted and readjusted, but no relief was afforded. She came to me with the conviction that something must be wrong with her spectacles. I found them entirely correct, but on inquiry I learned that she had lived in a house adjacent to a lot in which there had been digging during a number of weeks of the summer. I immediately suspected that it was a case of malarial infection, wrote to her physician stating my views, and in a few weeks she was perfectly well, and remained so, at this writing, some two years since.

A physician of about forty, with myopia, consulted me in regard to vertigo, which was very troublesome, and for which he had already seen a specialist in neurology. This specialist found want of equilibrium in the ocular muscles accompanying the myopia, and recommended that he should come to an oculist for a tenotomy. He came to me for this purpose. I tested his sight and ocular balance, and, at the same time, inquired into his general condition and habits. I found that he was overworking, and that he was stimulating somewhat in order to compensate for his excessive activity, that he was not

sleeping well, and so forth. I advised that he change his mode of life, not work so hard, have a change of air, and return in two weeks. When he returned, the condition of his ocular muscles was exactly the same. Of course, his myopia remained unchanged, but his vertigo had disappeared, and from that time to this, a period of some ten years, he lately told me, he had had no return of the symptom.

Such cases could be multiplied indefinitely from my practice. They are outlined here in order, if possible, to teach the practitioner into whose hands this volume may fall, the necessity of thoroughly considering the general condition and habits of a patient, before resorting to an operation for the restoration of that so-called "muscular equilibrium," which is not at all essential, in most cases, to good use of the eyes, with freedom from asthenopia.

A young man of 21, a student, treated by various oculists, on account of want of balance of ocular muscles; becomes steadily worse until the use of glasses is desisted from, and general treatment undertaken.

March 3d, 1893, X. M. C., 21 years of age, student. He has had severe headaches since he was 15 years of age. From the symptoms they appear to be what is known as migraine; he has considerable indigestion. About two years ago he was informed that these headaches depended upon his eyes, and since then he has been under the care of oculists, although a distinguished oculist told him that his eyes were not at fault. His eyes are now under the influence of atropine, having been so for three weeks. The use of the atropine has not relieved his condition, and he has never found any of the glasses, of which he has had various kinds, of any service. His father is a prosperous business man, with one eye of very different refraction from the other, but without asthenopia. His mother is a neurotic with very poor digestion, unable to do anything continuously. This young man is a blond, well formed, but of delicate structure. On examination he is found to have vision $\frac{20}{20}$ — without glasses; he has one-half a diopter of corneal astigmatism, and a low degree of hypermetropia; but even under the full influence of atropine, accepts only a glass of a quarter of a diopter. A diagnosis of neurasthenia and migraine was made. This young man was told to stop his atropine, and when his eyes came back to their normal condition to look after his health, and work without glasses. He be-

came quite ill from the prolonged use of atropine, but finally on April 19th had fully recovered and has been able up to this time of writing, one year latter, to go on with his work, without glasses and in comfort.

A young man has great business responsibility thrown upon him; his eyes break down; a diagnosis of want of muscular equilibrium is made; his internal recti are divided; after the use of prisms his astigmatism is corrected, but he becomes steadily worse, unable to attend to business.

April 17th, 1893.—H. R. T., aged 27 years, clerk.—Some two years ago this young man was obliged to take care of his father's important business affairs, almost alone, his father having become seriously ill. For six months he had great responsibilities thrown upon him, and he became very *nervous*, and all use of his eyes caused a headache. He used prisms without benefit, his internal recti were divided without benefit; he is now wearing cylindrical glasses, but is still unable to work. Another operation has been recommended. He is a slight, delicate-looking young man. His vision is $\frac{20}{20}$ —; he has one diopter of astigmatism in the right eye, with the rule, with the left perhaps a quarter of a diopter against the rule. He seemed to be wearing the appropriate cylindrical glasses for use at his near work, but he was using them all the time, although his vision was $\frac{20}{20}$ with one eye, and $\frac{20}{30}$ with the other, without them. My diagnosis in this case was nervous disease, and that his ocular symptoms were the result of his great strain when under such responsibility. I accordingly referred him to Prof. Charles L. Dana, who wrote me as follows:

"Mr. H. has some tremor, evidences of vaso-motor irritability, a tubercular history and physique. I think his headaches are due to a general nerve-weakness. I have put him upon cold baths, exercise, diet, and mineral acid tonic. I think such treatment ought to be curative. If not I would look over a tubercular history."

It is too early to say what will become of this young man, but I think the average practitioner of large experience will agree with me, that his ocular symptoms are but a very small part of his troubles, and that it was a mistake to assume that he could be cured by tenotomies or prisms, or any kind of glasses.

A general practitioner sends a young man to the oculist for advice, on account of his headaches. They are relieved by quinine.

January 11th, 1893.—L. H. R., age 22, sent by Dr. X. For about seven years this young man has been subject to headaches at times.

He thinks they are caused by the use of his eyes, but there is some pain and blurring of vision when he uses them. He lives in a notoriously malarial district. He had chills and fever nearly every year of his boyhood, up to seven years ago. He had a chill followed by fever two months ago, but this chill was not followed by another, although he took no quinine. His vision is $\frac{20}{20}$ + on each side and he rejects glasses. He has one-half a diopter of astigmatism with the rule. A diagnosis of malaria was made, and quinine was prescribed. In one week he was better, in two weeks he was apparently well. He remains so one year later, although engaged most actively and continuously in the use of his eyes. This case is interesting because a general practitioner of distinction, on hearing his story, without hesitation recommended him to get glasses, as being the proper remedy.

These cases, as I have said in the beginning, could be multiplied, but they are sufficient to indicate my views on this important subject—that is, that there is a tendency in all circles of the profession, once having under-estimated the importance of the eyes to the general condition, now to over-estimate them. The pendulum has swung too far.

The nomenclature that has been introduced into ophthalmology, to describe weakness of the muscles should disappear with the demonstration of its uselessness. The measurement of insufficiencies, by the ingenious instruments invented for that purpose, should be abandoned, as being entirely unnecessary and misleading. In the laboratory where muscular force is measured, they may have some value to the physiologist, but I think clinical ophthalmology is much better without them.

It having been pretty thoroughly established that errors of refraction are the rule among well people and not the exception, the next thing naturally is to determine how many well people—that is, well as to asthenopia and nervous symptoms—have what is called muscular equilibrium.

I have recently investigated these conditions of muscles, which are said to be the prominent, if not the chief, factors in causing neuropathic conditions, and I present the results herewith. The investigations were made by one of my staff, Dr. Deynard of the Manhattan Eye and Ear Hospital, with the phorometer, with strict attention to the details laid down in the recent writings upon this subject. I personally have never

examined the cases. Dr. Deynard has been perfectly untrammelled in his investigations.

One hundred and three persons who did not have any trouble with their eyes that they knew of, who read and wrote and sewed, without headaches or asthenopia, who had no vertigo, chorea, epilepsy, hystero-epilepsy, or insanity, were selected as objects for testing. Eighty-three were aural patients attending the Manhattan Eye and Ear Hospital; six were friends who came with them; eleven were physicians; one was a music teacher; one was a servant, and one a detective. Seventeen, or sixteen per cent, were found to have muscular equilibrium; 84, or eighty-one per cent, had a want of muscular equilibrium, of these 27, or twenty-six per cent, had deviation outward, insufficiency of the interni, and 74, or seventy-one per cent, deviation outward in accommodation; 16, or fifteen per cent, had deviation inward, insufficiency of the externi; 7 had deviation downward in accommodation; 11, or ten per cent, had a tendency of the right or left visual line upward; 24 had deviation inward in accommodation. A re-examination of five of these patients, showed a change in the muscular examination from that found at first. This is an important observation, since it proves, as asserted, that the muscular power in the same eyes is not fixed, but variable.[1]

Hence it is seen that any series of cases founded upon certain ocular insufficiencies cannot be said to be proven when the existence of these insufficiencies is shown, for they may exist in connection with entirely healthy nervous systems, just as errors of refraction may. The value of observations founded on such tables, is now no more than the previous tables founded on errors of refraction. Not only does all the world have faulty refraction, but very few people possess equilibrium of the ocular muscles.

The capacity for great intellectual work with a high degree of muscular insufficiencx, is well shown by the following extract from a letter relative to the perception of distance by Sir William Rowan Hamilton, Astronomer Royal of Ireland,[2] printed in his

[1] "Astigmatism, its Relative Importance in Asthenopia due to Errors of Refraction," Medical Record, March 26th, 1892.

[2] I am indebted to Dr. Dennet for this quotation from the life of this eminent savant.

biography: "Though I habitually see a double universe, yet a marked improvement has taken place within the last few weeks in my power of seeing single. This I attribute to my having lately, for the first time in my life, bought a stereoscope and used it at leisure. A friend within a few minutes' walk of me has long had a stereoscope apparatus, but years elapsed before I could catch the effect at all. With each eye separately I saw a good relief, but it is 'two years ago' that I first was able to see that *tertium quid* which is the true result of the stereoscope, and certainly it greatly astonished me" (written by Hamilton to De Morgan at fifty-eight).

Hamilton also states that on the evidence of his friends he did not squint, and his photograph shows that he did not do so in any marked degree.

The study of the causation of disease, is certainly a very important one, but it is almost as puzzling at times as the theological problem of the origin of evil in the world. Yet some things we do know. If a man lives in a malarial swamp and intermittent fever attacks him, or if he drinks water polluted with typhoid bacilli and gets typhoid fever, or if he is exposed to a case of small-pox and breaks out with this disease, or if after prolonged exposure to wetting he is attacked with acute rheumatism, we have no difficulty in saying as to where the cause of his disease is to be found. But no philosopher will conclude that cholera is caused by insufficiency of the ocular muscles, because a large proportion of those seized with this disease, as is certainly true, have such an insufficiency. The true philosopher will recognize in nervous maladies a series of causes acting together, and at the bottom of them all, in this country at least, will be found that illy defined condition of which we know so little, but of which we shall know more, called nervous exhaustion.

CORRECTION OF ASTIGMATISM ALONE, WITH NO EXISTENT HYPERMETROPIA.

The causes herewith given show how correction of astigmatism may be sufficient to relieve asthenopia, without correction of hypermetropia.

CASE I.—A neurotic person, with headaches, gets relief from the correction of astigmatism only.

Mr. W——, aged 30. This patient was sent to me by Dr. C. L. Dana, who wished his eyes examined, not that Dr. Dana supposed that all his symptoms were caused by his eyes. He said that he had been subject to headaches for the last ten years; there is constant pain in his forehead, vertex, and occiput, and at times a sharp pain starting from the right eye and extending over the right side of the head to the back of the neck. He does not think his eyes cause his headache, but his eyes pain him when he uses them. His general health is good. He is wearing glasses of + 0.50 D. spherical. He has a sister and brother who were relieved of headaches by using glasses for astigmatism. His vision is $\frac{20}{20}$ in each eye; becomes $\frac{20}{15}$ by using a glass of + 0.50 D.+0.50 c. 90°. The ophthalmometer shows him to have only 0.75 D. with the rule, on the right side, and 1.25 on the left. He was ordered a + 0.50 c. 90° for the right eye and for the left + 0.75 c. 90°. Two weeks afterward the patient came in to say that he did not have so many headaches, did not frown, glasses seemed to be a rest to him, liked them very much, and four weeks later he said the same. This patient has considerable hypermetropia, besides the astigmatism. It is my belief that such cases of astigmatism are usually much benefited by cylindrical lenses, although these headaches do not entirely disappear. Less neurotic persons will sometimes tolerate as high a degree of astigmatism without headaches and without asthenopia. This is what I should call a mixed case.

CASE II.—A clerk, who has always had headaches at intervals, finds ocular relief from the correction of astigmatism.

Henry J. S——, 19 years of age. A clerk by occupation. He states that he has been subject to headaches all his life, his eyes pain him on use, blurring at times. His general health is good. His headaches are in his eyes and run up to his head; he sometimes wakes up with them, but he gets worse on use of his eyes. His vision in the right eye is $\frac{20}{20}$—; becomes $\frac{20}{20}$ by using + 0.50 c. 90°, same result on the left side. At some moments he declines all glasses on the left side. This is one of the eyes in which the cornea moves under the instrument, and it is very difficult to measure with the ophthalmometer, but we discovered at last that he had 1 D. with the rule at 65°, that is, 25° off from the vertical in the right eye, and 1 D. with the rule at 90° in the left. He had 1.50 D. of hypermetropia, and was ordered + 0.50 D.+0.50 c. 65° in the right, and + 0.50 c. 90° in the left. Fourteen days after he writes: "I find the

glasses you prescribed for me have been a great help; have had no headaches since, and my eyes feel very much rested after a day's work." Nothing has been heard from him since.

Case III.—A lady in good health, nearly forty, has asthenopia in the evening; she gets relief from the correction of astigmatism only.

This lady complains of asthenopia in the evening. She is in fairly good health, not particularly robust. Her vision is $\frac{20}{20}$ + in each eye. She has 2 D. of astigmatism with the rule. Her general refraction is hypermetropia. She was ordered a + 0.75 c. 90° in each eye for close work. She came six months later to see me, on account of another patient, and she told me that her asthenopia had been entirely relieved, that her glasses were perfectly comfortable. This is an interesting case, from the fact that the lady is nearly presbyopic, aged 37, and that she is able, without any correction of the general hypermetropia, to get on in perfect comfort with the correction of the astigmatism.

Case IV.—Blepharitis and asthenopia; relief from correction of astigmatism.

Mrs. D——, aged 35. This patient suffers from asthenopia, and chronic blepharitis. She was found to have nearly normal vision, and accepted cylindrical glasses. On the right 1 D., on the left 0.50 D. Her refraction was hypermetropic. The ophthalmometer made the corneal astigmatism 1.50 D. on the right side, and 1 D. on the left. She was advised to wear + 0.75 c. 90° and + 0.50 c. 90° on the left for close work, with no correction of the hypermetropia, and two months after she reported that her glasses were perfectly comfortable.

Case V.—Headaches and double vision; correction of astigmatism only; relief.

Miss A. D——, aged 28. This patient has had many headaches, for which she has worn + 0.50 D. and + 0.50 c. 90°. At times she sees double. Her vision is $\frac{20}{30}$ —. By the ophthalmometer she has 1 D. of astigmatism in each eye, with + 0.50 c. 9°. Her vision becomes $\frac{20}{20}$ —. She had three diopters of hypermetropia in each eye, but this was totally disregarded; + 0.50 c. 90° ordered for each eye, and six weeks after she wrote that her glasses were comfortable, and that the headaches were less frequent. This again was a neurotic case in which the astigmatism became the last pound to break the camel's back.

Case VI.—Double vision; headaches; relief by correction of myopia and astigmatism.

Maria C——, aged 11. This young girl complained of headache and of seeing double. Her vision is only $\frac{20}{100}$ in each eye. By the ophthalmometer she has 3 D. of astigmatism with the rule. The prominent feature in this case is the marked insufficiency of the interni, and the occasional double vision. Her refraction was myopic. She was ordered a + 1 D. in the right eye, added to a − 1.75 c. 180°, and in the left a − 5 D., added to a − 1.50 c. 180°, with which her vision became $\frac{20}{30}$ in the right eye, and $\frac{20}{40}$ in the left. She was seen one year after, when she stated that she was much more comfortable, very much improved, never sees double, but her eyes "get twisted sometimes, but they soon get untwisted." The concave sphericals were increased, but the cylindricals remained the same. This case illustrates the fact that positive double vision may be entirely relieved by the correction of the astigmatism. I have never asserted that prisms may not in some cases do the same thing, but with a correction of the refraction, muscular insufficiencies are fundamentally cured, not merely assisted by crutches.

CASE VII.—Double vision; migraine; partial relief from correction of astigmatism.

This patient has been subject to headaches since she was a girl. The eyes do not pain her, but she has "some doubling of vision" when she has the headache. Sees objects double. There was no double vision when she visited my office. The pain was chiefly over the orbit, and then in the back part of the eye. The diagnosis, by Dr. Graeme Hammond, who sent her to me, was migraine. Patient said this could be easily induced by anything requiring constant use of the eyes. Except being anæmic, patient was well. Her eyes had been put under the influence of atropine before she came to the office. With the ophthalmometer, on the right side, she was found to have 1 D. of astigmatism with the rule, the axis being from 30° to 35° from 90°. In the left eye she had 1 D. with the rule. She was advised to wear, for close work, on the right side, + 0.50 D. + 0.50 D. c. 45°, and on the left, + 0.50 D. c. 90°. Her vision was $\frac{20}{20}$ in the right eye, and $\frac{20}{40}$ in the left, with these glasses. These glasses proved to be perfectly comfortable. Six months later, the patient stated that she could read all the evening, but she could not sew, and she had an occasional sick headache, but not so many as formerly. She liked her glasses very much, and was disposed to wear them all the time, to prevent what she calls dizziness and double vision. The patient is still anæmic and neurotic. I think this she will always be, but the glasses are great palliatives.

CASE VIII.—The following case illustrates the interesting observation that correction of the astigmatism is sufficient, where there is a very slight degree of astigmatism against the rule, and considerable hypermetropia.

Mrs. A——, aged 36. This lady has had trouble with her eyelids for five or six years. Has blepharitis ciliaris; no asthenopia. What I observed in 1878, in my first paper on the relations of blepharitis ciliaris to errors of refraction, was markedly true here in regard to the absence of asthenopia. Patient's vision was $\frac{20}{20}-$. With the ophthalmometer she had 0.25 D. astigmatism against the rule. On some examinations with the ophthalmometer she seemed to have no astigmatism, but we finally concluded that there was separation of the mires, to the extent of 0.25 D. in the second position. She was ordered + 50 c. D. 180° in each eye. Three months later, the patient writes that she has had no trouble since using the glasses.

CASE IX.—Asthenopia; relief from correction of astigmatism alone.

Susie L——, aged 16. November 14th, 1891. The patient's eyes smart, burn, and pain on use; occasional headaches. The trouble has existed but a very short time. Is using her eyes eight hours a day, sometimes ten hours. Her vision is $\frac{20}{20}+$ in each eye. She has 1 D. of astigmatism, and her eyes are hypermetropic. She was ordered a + 0.50 c. D., 90°, and three weeks later she writes me: "My eyes are not at all painful, and are much improved from using the glasses."

CASE X.—A case in which correction of the hypermetropia and astigmatism was not as beneficial as correction of the astigmatism only.

An insurance underwriter, aged 27, uses his eyes all day; has had trouble with them since he was 12 years of age; watering, tired feeling, etc. He began to wear glasses in 1886. He has had excellent advice, but has always worn spherical as well as cylindrical glasses. He has 0.50 D. of astigmatism against the rule. There is 1 D. of hypermetropia by the ophthalmoscope. Judging from the records of competent men which he brought with him, he had much more under atropine, for he was wearing as much as + 4 D. sphericals added to his cylindrics. He was ordered + 1 c. D., 180°, for the right eye, +0.75 c. D., 180°, for the left eye. On December 22d, he writes: "The glasses you prescribed for me have not only relieved me from all the headaches I have had so long, but have been as a new pair of eyes to me."

This case illustrates in a marked way the general truth that the astigmatism is often the chief factor in producing asthenopia. This patient has had more comfort under correction of the astigmatism alone, than when the hypermetropia was also corrected. But, as has been already said, we must always regard a considerable degree of hypermetropia as a normal condition; and astigmatism even by itself, although more disturbing, as a rule, than hypermetropia, requires, so to speak, a certain setting, in general neurotic conditions, in over-use of the eyes, nervous exhaustion, the coming on of presbyopia, and other concurrent factors, before even it, will produce asthenopia. The almost complete uselessness of paralyzing the accommodation, when we can now accurately and quickly determine the corneal astigmatism by the ophthalmometer, is also incidentally shown by the cases.

I do not claim at all that persons with a considerable degree of hypermetropia, also having 1 D. of astigmatism, with the rule, may not do perfectly well for years without the correction of the astigmatism, wearing glasses that neutralize a part of the hypermetropia only. I have treated hundreds of cases in this way, before I began to use the ophthalmometer, and got very good results. I merely think that the simpler way to prescribe for these cases is to correct the astigmatism, and to allow the patients to compensate for their hypermetropia by a more vigorous use of their accommodation, but when these patients with that degree of astigmatism come to presbyopia, they will be much better off with the astigmatism corrected. I prefer, in the light of my present experience, in young persons, to try what effect correction of the astigmatism alone will have, before adding spherical glasses. In all but exceptional cases, the correction of the astigmatism alone will, I believe, give the best results.

OPHTHALMOSCOPIC APPEARANCES.

The ophthalmoscopic appearances in regular astigmatism of a high degree may readily be understood. Low degrees, such as one diopter, will hardly, except in observers of the greatest experience, make any perceptible influence upon the

appearance of the optic papilla and the retinal vessels. What the observer is chiefly to concern himself with, in using the ophthalmoscope in errors of refraction and accommodation, is to carefully exclude, or include, as the case may be, minute opacities of the cornea, of the lens, or vitreous, or changes in the retina, the nerve, or the blood-vessels. Except in very young children, who will not hold their eyes still for an examination with the ophthalmometer, it will not be necessary to use the ophthalmoscope or retinoscopy, in order to determine the existence of astigmatism. In some such young subjects we are sometimes obliged, for lack of ability to make an exact diagnosis, to content ourselves with an approximate correction until they are old enough to be amenable to discipline.

Migraine has been quite extensively supposed to be dependent upon astigmatism and on quite plausible grounds, but he who expects to cure many cases of migraine, or sick headache, by the use of glasses will be grievously disappointed. In a person with a decided error of refraction uncorrected, especially hypermetropic astigmatism, the frequency of the occurrence of *sick headaches* may be lessened, but this is all. As I long since pointed out,[1] migraine usually becomes less troublesome about the time that presbyopia comes on, and yet this is often just the period when an astigmatism uncorrected first manifests itself. More and more as we examine into the consequences of uncorrected errors of refraction, we find them limited to the eye itself.

In regard to muscular asthenopia, one thing more should be said. When we correct strabismus we are always content with removing the manifest deformity dependent upon insufficiency of the muscles. We never cut and cut again for insufficiencies that the phorometer may declare. If those who advocate tenotomies for latent insufficiencies are right, they ought, by all the laws of logical deduction, to continue their operations here also, until muscular equilibrium has been reached. But all practitioners are, I believe, content with glasses to preserve the equilibrium of the eye, and maintain the result of the operation, to

[1] New York Medical Journal, April 5th, 1890.

wit, parallelism. This is what I advocate for muscular insufficiencies or weakness due to errors of refraction.

The most deplorable results have occurred, in my own observation, in consequence of the long-continued effort to restore the muscular balance of the eyes. In two cases known to me, enucleation of a sound eyeball has been performed at the request of the patient, who, having followed all the steps in repeated efforts to obtain the unattainable, had become so morbid on the subject as to sacrifice one of the most important of the human organs, with which he was able to see distinctly, although it performed its functions with some difficulty, either real or imaginary, in its co-ordination with its fellow. One young patient, with great capacity and well grounded by education to make a useful man, I rescued from such a mutilation which he was urging upon his oculist, by my advice that he should first spend a few months in a hospital for the insane. To turn the attention of many patients away from a contemplation of the working of their eyes, will be the duty of many an oculist who is consulted for an error of refraction, which has caused a want of equilibrium of the ocular muscles.

Occasionally, double vision is one of the consequences of errors of refraction, which can often be entirely removed by the use of appropriate glasses, although it is generally assumed that this condition is one that must, of necessity, require tenotomy. It is remarkable what results are sometimes accomplished, especially in hypermetropic astigmatism, on removing this disagreeable symptom, and this without the aid of any prisms whatever. Of course, if the double vision is constant, it will often be necessary to perform an operation. Some of the cases just given illustrate this point.

It is not an uncommon thing for young children, even, to complain of double vision from weakness of the external recti in hypermetropic astigmatism. This will be invariably corrected by the use of cylindric glasses, and requires no prisms.

Recently a child of six years of age was brought to me who made this complaint, saying very intelligently that she saw double while she was playing house, and that had occurred to her several times. On examination, I found she had 3 diopters of astigmatism in one

eye and 1 diopter in the other. I have great confidence in believing that she will cease to have double vision on wearing correcting glasses, and she will not be obliged to wear them except when at near work or play.

HISTORICAL NOTES ON THE DISCOVERY OF ASTIGMATISM AND ITS CORRECTION BY CYLINDRICAL LENSES.

Donders[1] found it remarkable that astigmatism up to his time was almost exclusively treated of in English literature. In Mackenzie's illustrated treatise he found all that was known on the subject, and this had been discovered by Thomas Young and the royal astronomer Airy. The latter had a high degree of compound myopic astigmatism in his own eye which he carefully investigated. Stokes, also an Englishman, invented a lens for determining the degree of astigmatism. Dr. Goode also reported some cases, one of them, like Airy's, in his own eye. After Goode, Thompson reported cases, also in England.

In our own country Dr. Isaac Hays recorded two cases in an American edition of "Lawrence on the Eye," for which the optician McAllister made correcting glasses. Strange to say, nearly all of the cases reported up to Donders' time were of the less frequent variety, myopic astigmatism. Wharton Jones in his "Manual" (London, 1855), and Sir William Wilde in the *Dublin Journal of Medical Sciences*, boldly announced, and correctly too, but without adducing proof, that the seat of astigmatism was in the cornea. This was in the face of Thomas Young's observations, that would, as Donders says, have led them to look for it in the lens. The Dutch physiologist continues: "We see that in science also the quotation is sometimes applicable, '*audaces fortuna juvat.*'" One of my patients, the late General Terry of the United States Army, who had myopic astigmatism, with the aid of an optician corrected his own defect about the year 1858. It was not until after the war had ended, that he learned that astigmatism was everywhere recognized—when he sought and secured a better correction than he had hitherto had.

Since but one continental observer of astigmatism appeared until Donders' time, and he long after the reports of Young and Airy, the credit of preparing the way for the full revelation of the diagnosis and correction of astigmatism, made in Holland, must be given to Great Britain and our own country.

[1] *Loc. cit.*, p. 539 *et seq.*

CHAPTER XXXI.

PRESBYOPIA.—GENERAL REMARKS AS TO THE ADJUSTMENT OF GLASSES.

Definition.—A Disease of Accommodation.—Physiological Causes of Presbyopia.—The Immunity of Watchmakers from Asthenopia.—Prescribing Glasses.—Presbyopia complicated with Myopic Astigmatism.—Methods of Testing for Presbyopia.—Table.—Donders' Rule.—Variations of the Rule.—Inventions which Lessen the Necessity for Over-Using the Eyes.—The Choice between Spectacles and Eyeglasses.—A Mydriatic Not Necessary in Prescribing Glasses for Presbyopia.—Concluding Remarks as to the Method of Adapting Glasses for Errors in Refraction and Accommodation.—The Importance of Careful Ophthalmoscopic Examinations.

DEFINITION.—*Presbyopia* (πρέσβυς, *an old man;* ὤψ, *eye*), *consists of a recession or removal of the near point of vision.*

This change, which is a senile one, and which ultimately affects every eye, is naturally a great inconvenience to hypermetropic eyes, while in myopia, the recession of the near point may make it easy for the subject of it, to read or pursue occupations on fine objects near at hand, without glasses, which is a very great boon. This fact has led to the opinion, sometimes expressed, that a moderate degree of myopia is the best vision for those who use their eyes very much upon near objects.

Presbyopia is a condition dependent upon the accommodative power, a disease of the accommodation. In advanced age, not only the near point but also the far point recede. This is due to causes that will be discussed a little later on. From what has gone before, it will be readily understood that presbyopia must be inconvenient, or, at least, require aid for its relief at an earlier period in eyes with a very short axial diameter, than in those approaching the ideal or standard eye, where parallel rays are united upon the retina without the slightest accommodative effort, or, as has just been indicated in myopic eyes, that are adapted for the rays coming from near objects. For example, a person of forty years of age, who began and

continued life with a hypermetropia of three diopters, to which is added, let us say, a corneal astigmatism of one diopter, will need a much stronger glass for reading, than a person of the same age who has only a half diopter of deviation from an ideal eye, while a person with three diopters of myopia may go on, in spite of the senile changes in his eye that constitute presbyopia, and read and write without the aid of glasses until old age has been fully entered upon. In myopia of six or seven diopters the whole of a long life may be passed without the need of glasses for near objects. The causes of presbyopia have been at work in all these eyes alike, yet they have acted upon different conditions.

The physiological causes of presbyopia, in the light of our present knowledge, may be said to be of a threefold character:

I. A diminution in the contractile power of the ciliary muscle.

There is scarcely a muscle in the body, that begins work at so early a period, and continues it so unremittingly, as does the ciliary. The infant of a few weeks of age begins to accommodate for near and far vision. This is continued with considerable vigor, too much so, if unchecked, in the early years before school life begins. When the latter period is reached, its exercise is almost unremittent during the hours not given to sleep, and sometimes under most unfavorable circumstances, that is to say, with poor illumination, bad posture, and with badly printed text-books, with type too small. This latter difficulty is increased in countries where the Roman characters have not been adopted. There is, perhaps, no muscle for which it is more difficult to provide perfect rest, except from the unceasing activity of the ultimate muscular fibres, than the ciliary muscle. If we secure abstinence from reading and writing, sewing and the like, there remains still the uncontrollable activity of the accommodation in eating and drinking, in turning from one object in the landscape or room, to another a little nearer, back again, and so forth. With the dawn of youth its power begins to decline, especially if over-exerted, and if too continuously employed. Especially is this so, if it be in an anæmic subject or one destitute of an average degree of vigor. The aboriginal inhabitants of our country, the fron-

tiersman, the scout, the sailor, the country gentleman leading an out-door life, usually have a greater accommodative power, and a clearer distant vision, than the student, the neurotic invalid, or the bookkeeper and the man of letters. To this there may seem to be exceptions, but usually they are only apparent ones, or they really prove the rule, that excessive use of the accommodation for near objects, brings on presbyopia at an early age. It is true that watchmakers retain their accommodative power for a relatively long period. They seem to be among the less frequent in the occupations of those who seek relief at the hands of the oculist. Thus among one thousand cases applying for aid at the Manhattan Eye and Ear Hospital, there was no watchmaker as against many bookkeepers and seamstresses.

This comparative immunity of watchmakers, may be due to the fact that their close vision is chiefly with one eye, and always with the aid of a convex glass. Their accommodation, although they are constantly looking upon fine objects, is not really strained, as with those who use both eyes together and call in the converging muscles to act with the ciliary. This first factor in the production of presbyopia may, therefore, vary in different individuals, in the effect with which it acts.

II. There is, however, a second factor in the production of presbyopia, that is to say, a rigidity of the fibres or the capsule of the crystalline lens, which renders it difficult or impossible for it to undergo as rapid and great a change in shape, that is, an increasing of its convexity. This increase of convexity is, of course, essential to the refraction and focusing of divergent rays. Any diminution of it, is an incident of presbyopia.

III. There is, perhaps, also an absolute flattening of the lens, on account of increased density (Stellwag) which shortens the axial diameter of the eye, and constitutes what Donders called acquired hypermetropia.

These three factors in the average, non-myopic eye, are usually sufficiently powerful to bring a person to the need of weak convex glasses at the age of forty, especially if that person be required to use the eyes at very close work. If there be a corneal astigmatism of one diopter added to this, it will usually, although not always, be more comfortable to the patient

if a cylindric glass of half a diopter, be added to the 0.50 D. which is the first glass required by a subject of the character just indicated. In cases where there is a very low degree of hypermetropia added to the astigmatism, it may be sufficient to give the beginning presbyope a glass for a year or so, that will simply correct the astigmatism. Such a glass is actually more comfortable in many such cases than one with an added spherical. I am now speaking of hypermetropic astigmatism. Where there is myopic astigmatism and emmetropia in the other principal meridians, it will be necessary for a few years to correct this only, which is done by ordering a convex cylindric glass for the emmetropic meridian. For example, if a patient of forty years of age have a myopic astigmatism of one-half a diopter, it will be proper to order for him a positive cylindric glass of that degree, with the axis at 90°.

It is the increasing density of the lens, and its consequent flattening, which causes the far point also to recede in advanced life, but this does not come on for some years after failure of the power of the ciliary muscle has been observed. As a result of this recession of the far point, convex glasses are then required for distant as well as near vision.

Presbyopia complicated with myopic astigmatism in a man of 49 years of age.

A. R., æt. 49. This patient has myopic astigmatism of 1.25 in each eye, axis 180°. For reading then his presbyopia only affects the opposite meridian, the myopic meridian being well adapted for that without a glass. A convex cylinder is, therefore placed before the meridian, or at 180°. With his moderate degree of myopia, the time will come when he cannot read easily without a glass over the myopic meridians as well.

METHOD OF TESTING FOR PRESBYOPIA.

In the determination of the glass for the near point, the vision should always be tested for the far. If convenient, it is much better to have twenty feet for the tests. It is the habit of patients who consult an oculist for what they consider to be, and what is usually, simple presbyopia, to demur at this, and to exclaim that they "see perfectly well at a distance, they only require glasses for reading," and so forth. They do not see why

they should be required to be tested for distant objects, but a standard of prescription, can only be accurately obtained by the test for the determination of the existence of latent hypermetropia, its degree, if present, also the demonstration of the presence or not of corneal astigmatism, or even of amblyopia. The practitioner should not be deterred from the scientific although routine method of ascertaining the visual power with accuracy. Results somewhat startling to a self-satisfied patient, will disturb his preconceived ideas as to his power of seeing. That being once accomplished, and it is a very easy and rapid test with intellectual patients, the practitioner may prescribe the proper glass for reading or the like. Given an eye with $\frac{20}{20}$ vision unimpaired by convex glasses, with no corneal astigmatism, or less than 0.75, I lay very little stress upon the near tests. We may determine with great certainty on the plan of the following table. A person of forty or forty-three, without astigmatism of a diopter, and with no manifest hypermetropia, will require—

At 40	a glass of 0.50 D.
" 45	" " 1. D.
" 50	" " 1.50 D.
" 60	" " 2 to 2.50 D.

If manifest hypermetropia of two or more diopters exist, it will be necessary to add a glass of one or more diopters to the numbers here indicated.

The usual test for reading is No. 1 Jaeger or No. 1 Snellen, and as laid down by Donders, the rule is to order a glass with which this type (a specimen of which is found in Chapter VII.) can be fluently read at eight inches from the glass. This is intended to apply to reading ordinary type. It has proved itself to be a good working rule, during the thirty years or more that it has been employed. Yet like all rules it should be applied with some discretion. Many patients require glasses for various purposes, some for reading manuscript, at a distance of a foot or more from the eyes, clergymen and professors reading lectures in colleges for example. Others again need glasses for reading music placed on a piano. Bookkeepers also vary in the distance at which they work upon ledgers, and so forth. Donders' rule applies well for ordinary reading in an ordinary light, and although it is obvious, that books

with large type, require glasses giving less aid to the accommodation than do our newspapers, often printed with poor ink and small and worn type, there are few presbyopes who find it necessary to have more than one pair of glasses for all their ordinary work. The invention of spectacles and the accurate means now used to determine their choice, have given printers and publishers great latitude in the way of using small and well-worn type, a latitude which they have not been slow to avail themselves of. But oculists should set their faces against this means of overtasking the accommodative power of civilized and cultivated races, and advise the selection of good type, even for young persons with clear vision and vigorous ciliary muscle. Patients are

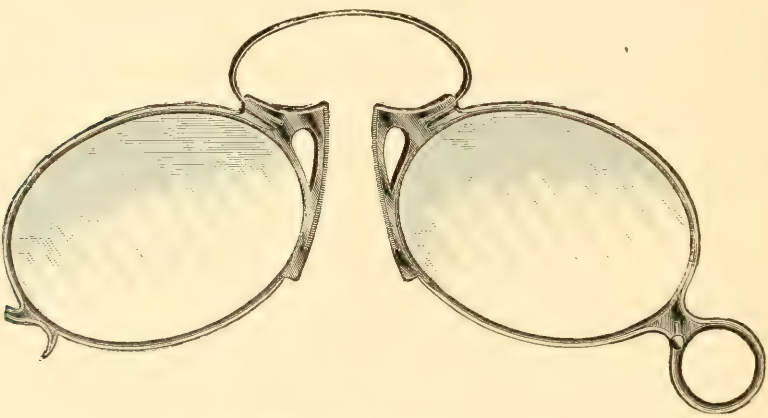

FIG. 172. MODEL OF SIMPLE EYEGLASSES.

sometimes suspicious of the tests with fine type, for, as they truly say, they do not read such type, yet it is better to make the test with it. The capacity to read No. 1 Jaeger fluently at eight inches removed, with a given glass, will generally determine that this is the proper glass for reading and writing. The tests made by oculists are usually with a very good light, while ordinary reading and writing are often carried on with that which is far from good. The test allows for this. The beginner may find it difficult to induce some patients to hold the test types at eight inches, even when they can read at that distance, for with preconceived ideas, they imagine that they are to be compelled to hold their books at that distance for their ordinary life. It is better, therefore, after having positively determined

that the test lines may be read at eight inches and not nearer, for if they can be read at six or seven inches the glasses will invariably be uncomfortable, to give the patient an ordinary printed book, a newspaper or the like, and decide after they have read in a natural way, holding the book as they are

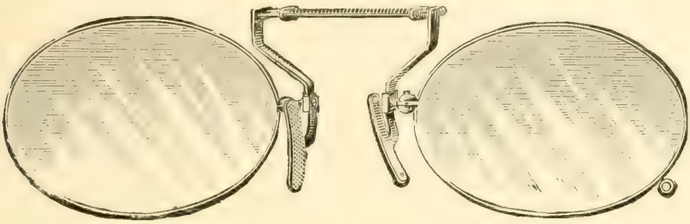

FIG. 173.—EYEGLASSES WITH MOVABLE HORIZONTAL BAR.

accustomed to hold it, whether the glasses are adapted for ordinary work.

The invention of stenography, and of the typewriter, and the practice of dictation associated with these methods, have been a great boon to presbyopes, and even to young business people, for they have greatly diminished the necessity for such continuous use of the eyes as was formerly necessary in conducting a large correspondence, in preparing matter for publication by editors and authors. These inventions have done much to les-

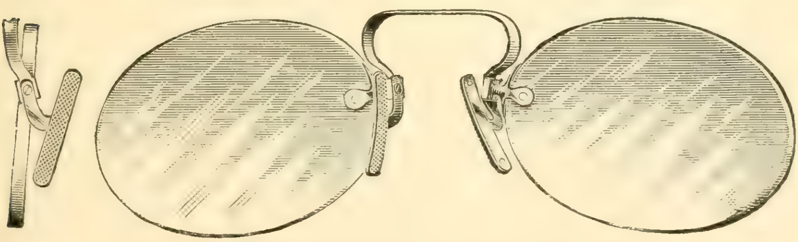

FIG. 174.—EYEGLASSES WITH SPRING AT NOSE.

sen the disadvantages to civilized eyes from the necessity of their over-occupation upon near objects.

PROPER FRAMES.—EYEGLASSES.

At this point, it may be well to urge the practitioner to see to it that the optician makes properly fitting frames or the glasses that have been ordered by him. At the same time,

the patient should be given a few words of advice that seems almost unnecessary, namely, that he shall not treat his glasses as if they were something that can be thrown down or bent out of proper position with impunity, but that they should be kept carefully cleaned and handled with delicacy, that they may do all that can be properly required of these invaluable aids to the work of life.

Formerly, I laid some stress upon the use of spectacles for prolonged work, for all persons, but after some considerable experience I am convinced that properly chosen eye-glasses are better for most persons for all purposes. But here, of course, the conformation of the nose and forehead will have something to do with the choice of frames for glasses. Children who are required to wear glasses all the time will usually find spectacles

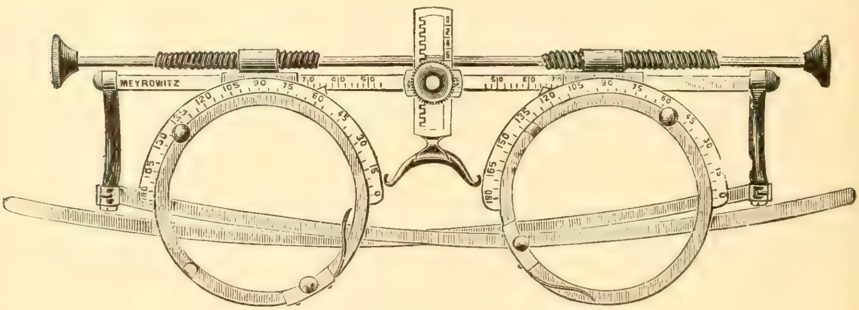

FIG. 175.—FRAMES FOR HOLDING TEST GLASSES.

better adapted to their needs, and myopes in general more often require spectacles, but presbyopes are usually more comfortable with eyeglasses. Since eyeglasses are generally considered more becoming than spectacles, young men, and especially young women, compelled to wear them should be allowed to choose the form of frame they may prefer, so long as they are of good size, so as to fully cover the eye, and with the centres corresponding properly to the pupil. Astigmatics should be warned of the uselessness and possible harm of glasses so carelessly put on as to actually change the position of the axis of the cylinder, yet even they, may wear eyeglasses, if proper precautions are taken. It only remains to be said, that in no cases of mere presbyopia, will it be necessary to use a mydriatic to properly select a glass. Such a practice, which has been mentioned here and

there as a proper one, is only one that will very much annoy the patient, without adding at all to the facility with which the proper glass is chosen.

CONCLUDING REMARKS AS TO THE METHOD OF ADAPTING GLASSES FOR ERRORS IN REFRACTION AND ACCOMMODATION.

As this book will come largely, it is hoped, into the hands of those who are beginners in ophthalmology, I recapitulate, at this point, the method of making an examination of a case which proves to be one requiring glasses.

1st. Make a thorough examination of the patient's vision with both eyes open, and also with each eye separately.

2d. If the vision be $\frac{20}{20}$ or $\frac{20}{20}$ — in each eye, proceed to use the ophthalmometer.

3d. If the vision be only $\frac{20}{30}$ or less, make a careful examination for corneal opacities, lesions of the lens, or, these being excluded, of the back part of the eye. If the bad vision cannot be accounted for by this examination, then proceed to the determination of the presence or absence of corneal astigmatism.

4th. If 1 D. of corneal astigmatism, with the rule, be found, and the vision be or —, the patient will almost invariably be hypermetropic and have hypermetropic astigmatism, corrected with a positive cylindrical glass, axis 90°.

5th. If the patient have this degree of vision, it is a matter of very little account whether or not he accept, that is, see as well with the convex cylinders as without them, and I have no hesitation in ordering them, with the confidence that they will relieve the asthenopia. If he have, as is often the case, a higher degree of astigmatism, with the same vision, the glass will be ordered accordingly. In this class of cases, very little attention need be paid to the patients' own statements about the glasses. They are subjective in the highest degree, and, in my opinion, much time is wasted in seeing whether or not they will accept spherical glasses, as they often will, in addition to the cylindric.

6th. In another class of cases, where there is decided asthenopia and no astigmatism, or half a diopter against the rule, there will be no hesitation in prescribing the proper cylin-

ders, even if the patient does not know whether or not he sees better or as well with them.

7th. When, however, the ophthalmometer declares the axis not to be at 90° or 180°, the subjective examination with the cylinder should be made, and, as a rule, that examination agrees entirely with the results of the ophthalmometer. Should it not, the patient should be sent away, and the examination repeated at a later day, and if the discrepancy persists, I invariably prescribe according to the readings of the ophthalmometer.

But we should be certain that no error is made in the position of the head, or in other respects, which would cause a false reading, and the patient should be warned that if the glasses are not comfortable in two weeks, he must return, when, if the discrepancy continues after this fair trial, we may conclude that there must be some lenticular astigmatism, and a mydriatic should be used to determine the refraction, with paralysis of the ciliary muscle.

If no astigmatism is found and there is, as shown with the ophthalmoscope, or by the test with glasses, considerable hypermetropia, the spherical glass is ordered which they will accept for distant vision. These cases form a large contingent. They are the simple hypermetropes.

8th. When, however, the vision is defective, and the ophthalmoscope gives no reason for it, we cannot be sure whether we are dealing with myopic or hypermetropic astigmatism until the tests are made with glasses. In young subjects, after ophthalmoscopic evidence shows distinctly that they are myopic, and the concave glasses are accepted, I prescribe them from the subjective examination. But if the fundus appears to be hypermetropic and they still prefer concave glasses, atropia should be used. But these cases are entirely exceptional.

9th. For presbyopic patients, if they have astigmatism, the spherical glass should be added to the cylinder, which will enable them to read No. 1 Jaeger at eight inches, fluently. They must be allowed, however, to read an ordinary book, holding it at such distance as may be comfortable for them in an ordinary light, and in some exceptional cases, I find that the reader will tolerate only a glass with which he can read No. 1 Jaeger distinctly at nine inches. In persons just on the bounds of presbyopia, say

at forty or forty-one years of age, without asthenopia, who have simply inability to see fine print at a proper distance, we may be very often content, for a year or two, with ordering a glass to correct the corneal astigmatism only, that is to say, the corneal astigmatism less that neutralized by the lens. Where there is myopic astigmatism and presbyopia, the positive cylinder will also often be sufficient to neutralize the presbyopia for two years or more after it shows itself.

10th. Great stress should be laid on the frames ordered for the glasses, but I no longer insist upon spectacles. I consider eye-glasses just as well adapted, if properly fitted; and they may be worn by adults or intelligent young persons for the correction of astigmatism.

In all this it must be understood that I am speaking of cases only that are clearly refractive cases, and not those showing ophthalmoscopic lesions. Where they exist, the cases come under the head of diseases of the eye, and not simply as those requiring glasses. I should, however, add that I do not assume, unless it is clearly proven, that a slight error of refraction, of itself, produces headache or inability to use the eyes.

I cannot lay too great stress on most careful ophthalmoscopic examinations, especially in persons of middle life, with reference to minute opacities of the lenses, which may cause considerable asthenopia, and be easily overlooked.

CHAPTER XXXII.

STRABISMUS.

Definition.—Causes.—Varieties.—Strabismus Convergens.—Unusually One Habitually Deviates.—Concomitant Squint.—Statistics of Refraction.—Amblyopia ex Anopsia.—Strabismus may be a Symptom of Cerebral Disease.—Functional and Organic Amblyopia.—Convergent Squint and Myopes.—Treatment.—By Atropia and Glasses.—By Operation.—The After-Treatment.—Results of the Operation.—Divergent Strabismus.—Refraction in this Form of Strabismus.—Insufficiency of the Interni.—Muscular Asthenopia.—Treatment for Permanent Divergence.—Strabismus Sursum Vergens.—Strabismus Deorsum Vergens.

STRABISMUS, *or squint* (*στραβίζω, to squint*), *is a deviation in the action of the external muscles of the eyeball, so that when one eye is fixed upon an object, the other is directed away from it.* It is caused by a want of balance between the power of the muscles. A rude simile of squint, may be made by comparing the ocular muscles to the reins by which horses are guided, one being shorter or stronger than the other, so that the head of the animal cannot easily be kept straight. Another definition of strabismus is, a *deviation in the direction of the eyes, in consequence of which the two yellow spots receive images from different objects* (*Donders*).

This deviation has many causes: Paralysis of a muscle or set of muscles of course produces it; but here we discuss that form of strabismus, in which there is no want of power of the muscles,—no paresis nor paralysis—but that condition in which they do not act in unison, and a deviation of the eye from a normal position results, although the power of the muscle to act singly remains unimpaired. Although all deviations of the eye, from the imperfect action of any muscle is properly called strabismus, technically, when strabismus is spoken of, without qualification, that form is meant, in which the cause is found in want of equal action of the muscles without any impairment of their power of motion when acting alone. The other deviations from loss of power of a muscle are comprehended under paralysis.

The four chief varieties of strabismus are strabismus convergens, strabismus divergens, strabismus sursum vergens, and strabismus deorsum vergens. The most important of these are the two former varieties. The first will now be discussed.

In strabismus convergens one eye is deviated inward, while the other is fixed upon the object. One of the eyes habitually deviates. This eye is generally more or less amblyopic, although not always so. In other cases, the subject squints, first with one eye and then with the other, scarcely seeming to have a choice as to which is used. In such cases, the vision is usually found to be fairly good with each eye and about the same with each; generally it is at least $\frac{20}{30}$. In this latter fact, is to be found the reason that one eye is used with about the same facility as the other. In all cases of non-paralytic convergent squint, by closing one eye and causing the patient to fix upon the object with the other, it is possible to bring out a squint in the shaded eye. If it be quickly uncovered and observed, it will be found that it now deviates inward, thus taking the place of the one that habitually squints. For the reason then, that on forced fixation with either eye, the other always deviates inward, in this form of strabismus, I discard the name concomitant squint, since all non-paralytic squint is concomitant. It seems to me an utterly unnecessary term. It is this concomitance that aids us in separating true strabismus from paralytic squint. The term *alternating*, as applied to cases that squint first with one eye, and then with the other, should be retained.

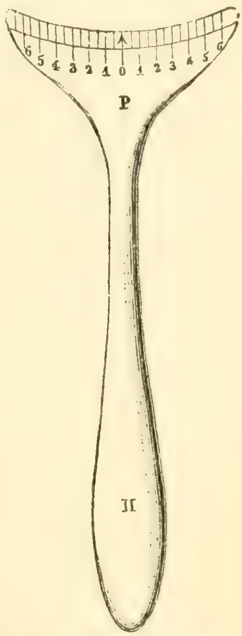

FIG. 176. — INSTRUMENT FOR MEASURING THE DEGREE OF DEVIATION IN STRABISMUS. This the patient is made to fix accurately with the non-squinting eye, when the instrument is held along the edge of the lid with the central mark exactly in the middle of the lid. The number of lines of deviation of the pupil from this will mark the degree of the squint.

It is proper also to still further describe strabismus by the adjective *periodic*, for there are cases, especially those in which the vision of one eye is about as good as that of the other, where the strabismus only appears at intervals, and then again disap-

pears. In these cases, it is most apt to occur after some exhausting illness, or great fatigue, or the like.

CAUSES.

The causes of strabismus convergens are not decisively settled, but the following facts are fixed in connection with it:

1. It is usually associated with hypermetropia and hypermetropic astigmatism. Of a series of 100 cases operated on by myself, there was:

Hypermetropia in both eyes, in	78	cases
Hypermetropia in one eye and hypermetropic astigmatism in the other	5	"
Hypermetropic astigmatism in both eyes	11	"
Hypermetropic astigmatism in one eye and myopic astigmatism in the other	1	case
Myopia in both eyes	2	cases
The refraction was unrecorded in	3	"
Total	100	

In an additional series of 121 cases, the refraction was noted to be as follows:

Hypermetropia in both eyes	75	cases
Hypermetropia in one, hypermetropic astigmatism in the other	15	"
Hypermetropic astigmatism in one, myopic astigmatism in the other	2	"
Hypermetropic astigmatism in both eyes	26	"
Hypermetropic astigmatism in one, mixed astigmatism in the other	2	"
Myopic astigmatism in both	1	case
Total	121	

Nearly all of the latter series were observed with the ophthalmometer. The proportion of cases of astigmatism is, therefore, greater.

I have found a very large proportion of cases of astigmatism, especially in the squinting eye. Had I used the ophthal-

mometer in the first series of 100 cases which I reported as above, I think the same proportion would have been shown. Strabismus convergens only rarely occurs in myopia, and then in myopia of a high degree, from causes that will be discussed later.

2. In about 75 per cent of cases, the vision of one eye is markedly less than that of the other.

There are some unsettled points, concerning which high authorities are ranged on opposite sides. It is unsettled, for example, whether the amblyopia above mentioned, is a congenital condition, or whether it is an amblyopia acquired as a result of the deviation of the eye, the image not falling on the same part of the retina in the two eyes, until the retina is finally blunted, *amblyopia ex anopsia* (from not seeing). It is settled that a certain degree of visual power is lost after the appearance of the squint, and that this part may be restored by an operation, or by glasses that will bring the eyes to parallelism. One case that illustrates the former statement occurred in my practice, when, in a squinting family, a child of seven years of age had no squint at the time of examination, but was said to squint at times. R. and L. V. = $\frac{20}{20}$ H. $\frac{1}{8}$. She accepted and wore + $\frac{1}{10}$. In four years after, this child came with a fixed squint, by preference in the right eye, and the vision in that eye was reduced to $\frac{20}{100}$; while the left, the non-squinting eye, remained at $\frac{20}{20}$. The examinations, first and last, were made with great exactness by competent men, the late Dr. Edward T. Ely and my present associate, Dr. J. B. Emerson, and I have no doubt of the truth of the observation. I advised an operation, but the case disappeared before I had the opportunity of making the crucial test of paralyzing the accommodation, and securing the best vision possible with glasses under such paralysis.

IMPROVEMENT IN VISION FROM THE OPERATION.

Up to this time, I have been unable to secure any better vision after the operation, than I have obtained before it, by the use of atropia and correcting glasses. Imperfect observation lies at the basis of much of the discrepancy of statement, as to the improvement of vision as the result of an operation. Patients of a certain class always see better after they have *learned*, not the letters

of the test-types, so as to memorize them, but after they have become accustomed to the tests (Pomeroy, Schweigger). We should be careful not to conclude that a patient sees better from the operation, because he then reads a line or so of Snellen more than he did before it was performed. That much improvement may be due to the cause just mentioned, and to the letting up in the spasm of accommodation which may exist, as well as to the proper correction of the anomaly of refraction. The fact that squint usually occurs before the child knows its letters, renders it difficult, if not impossible, to determine what the visual power is, except in a crude way. We are likely to remain long in doubt as to whether the amblyopia is congenital, and whether it of itself is one of the causes of the squint, or whether the amblyopia is always a result of the strabismus. If a few such cases as the one I have quoted can be found, and if it is proven that atropia and glasses do not very soon bring the vision back to the original normal standard, it must be admitted that those who believe in *amblyopia ex anopsia* have much on their side.

One of the first symptoms of cerebral disease (tumor) is sometimes strabismus convergens, not paralytic. In one sad case that was under my care, it was some weeks before true paralysis of the muscles occurred, although the squint was very marked and was concomitant. Subsequently, the paralysis was plainly apparent, and other symptoms, indicating the presence of a lesion in the brain. Although the ophthalmoscope revealed absolutely nothing, the vision declined after the squint was fairly established, from $\frac{20}{20}$ to $\frac{20}{200}$. I do not think this could have been referred to pressure, because there was no papillitis or change in the vessels. The amblyopia seemed to result from the abnormal position of the eyes. The child subsequently died of tumor of the brain. To say, however, that there is amblyopia after squint develops, an amblyopia resulting from a disregard of the image which does not fall upon the macula, but upon a less sensitive portion of the retina, is very far from saying that this is anything more than a functional disease, which may be immediately corrected, so soon as the eyes are in a state of parallelism, and proper glasses are adjusted, so that they can work together. The question is, Is

there an amblyopia depending on organic changes, which produces the squint, or does the squint have all to do in causing the amblyopia? In my judgment both statements are true; there is an organic and congenital amblyopia, which is never relieved—is never capable of being relieved, by any treatment; there is also an amblyopia which is cured under the circumstances just mentioned, an amblyopia which may be called *functional*. In the former case, the vision is defective on account of want of perceptive power from organic disease, even if we cannot recognize it. In the latter, the patient simply suppresses the image to avoid diplopia. Occasionally cases of con-congenital amblyopia are found, in which squint never seems to have existed, and in which there are no appearances of disease observed with the ophthalmoscope.

Javal has found that prolonged use of the amblyopic eye, after an operation for squint, has resulted in improvement of vision, although not immediately. His mode is a very thorough and lengthened one, lasting for years. Such an one I have not undertaken, but I have met with no encouragement in the cases where I have had the same eye bandaged three to four times a day and the fellow-eye exercised on fine print. With the earnest co-operation of the parents, I have had no results from this system, and I have long since abandoned it. I think all the benefit which results in curing the amblyopia is achieved in a very few days after the eyes are in a state of parallelism, and the proper glasses are adjusted. In other words, the functional amblyopia may be relieved in a short time, and the organic never.

The following facts show that organic amblyopia may cause squint. A patient operated on for cataract in one eye, while the other remains blind, recovering his sight in the eye operated upon, will often deviate the blind one inward. Again, in cases where both eyes have been operated upon, and for a time act together, if a membrane forms on one, disabling it for ordinary use, it may turn inward.

Then again opacities of the cornea occur, and subsequently the obscured or partially obscured eye begins to squint. It may be answered to this, as Donders does, that were these persons emmetropic, they would not squint, the opacity or obscuration

being only, so to speak, provocations to squint in eyes already adapted to this deformity. The investigations of our own time have shown that a moderate degree of hypermetropia is almost, if not quite, a normal condition. It cannot be that this condition of the refraction is of itself sufficient to cause strabismus convergens, although some plausibility is given to this theory because a hypermetropic eyeball generally exists with convergent strabismus. To this, however, must usually be added *anisometropia*, and persons who are not naturally anisometropic, but who have become so, may soon squint.

The convergent squint of myopes is only what Donders described it, the inability of the very much elongated eyeball to assume a straight position. The shape of the eyeball here is a mechanical or anatomical cause.

In all this discussion, it should always be remembered that strabismus is but a symptom. It occurs in central disease, in spinal disease, in disused eyes, as well as in paresis of the muscles. It has been so much the custom to write of the symptom as as if it were a disease, that it is now impossible to properly discuss convergent and divergent squint, except as coincident with, if not directly caused by, refractive anomalies. In doing so, however, it will be remembered, that squint not dependent upon a refractive error is fully recognized. All the evidence goes to show that a very prominent cause of strabismus is inability to procure binocular single vision. Such evidence is found in the fact already noted that patients who acquire opacities of the cornea and cataract in one eye readily squint.

Anisometropia frequently attends strabismus convergens. All careful observations of strabismus show that my estimated percentage of seventy-five, in which the vision is very much impaired in the squinting eye, is not too large.

The conclusions to which I have thus far come in the etiology of strabismus convergens of the type now under discussion—that is, occurring in connection is with refractive error—are:

I. Convergent squint is generally associated with hypermetropic astigmatism or hypermetropia.

II. It is probably caused by the congenital anisometropia, in the majority of cases, that is to say, by the inability to secure binocular single vision.

III. In a small contingent it is associated with equal vision in each eye. In such cases, the patient fixes with either eye alternately. Why the strabismus then occurs is to me uncertain. If it were merely from hypermetropia, why do not nearly all people who are not myopic squint?

IV. Opacities of the cornea, or occlusion of the pupil of one eye, very much favor the occurrence of squint in eyes of any refraction.

V. If strabismus convergens be caused chiefly by anisometropia and refractive anomaly, it is not congenital, but occurs at the age of from two to five years.

VI. If congenital squint or organic disease of the retina exists suspicion should be excited that it is caused by central disease.

Quite often little patients are brought to ophthalmic clinics with strabismus in its early stages and which is not paralytic, who are found to have *neuritis optica*. Every careful observer will take great pains to determine in a given case of suddenly occurring strabismus, that there be not some cerebral lesion. During dentition, certain children are apt to squint. This, I think, may fairly be ascribed to cerebral irritation, and not to refractive error, although here again it may be asserted that the conditions for squint exist in the refraction, or it would not have occurred. The pendulum, however, is swinging backward on this subject of the all-sufficiency of so-called refractive anomalies to cause innumerable symptoms. Since the rarity of the ideal or emmetropic eye has been demonstrated, we are becoming more guarded in ascribing strabismus to a very common, almost universal deviation from the normal type, such as a moderate degree of hypermetropia, the same in each eye.

It is possible that central irritation and central lesions, have more to do with even the ordinary type of strabismus convergens, than has been generally supposed. At any rate, as a symptom, it may depend on varied conditions, but I still incline to the belief that the most prominent factor in producing a convergent strabismus in children, is a very marked difference in the refraction of the two eyes. The attempt to see clearly brings on excessive convergence, which finally causes the permanent crossing of the optic axes. This, of course, is essentially Donders' theory. Where he laid great stress on hypermetropia alone,

I ascribe it to a high degree of hypermetropia or hypermetropic astigmatism in one eye, sufficient to produce what may be fairly termed an *organic amblyopia.* Such an eye is an undeveloped eye, and the rods and cones may be deficient.

This subject has been so fully discussed under the consideration of hypermetropia and hypermetropic astigmatism, that it is not necessary to say any more upon it at this point. The etiology of strabismus cannot be said to be settled. We can only, I think, as yet, produce the facts which have been observed in connection with the condition, and, according to the individual trend of mind, conclude which of the varied conditions as to causation are correct.

But the *myopathic* or *muscular* theory, that changes in the muscles themselves have produced the contraction, in my judgment, has no position whatever. That there is in long-continued squint an apparent shortening of the muscle, is evident to every observer, but it is only apparent, as can be demonstrated by the use of a mydriatic, by which the accommodation is paralyzed, when the squint can often be overcome, even in long-standing cases. Hansen-Grut's innervation theory does not seem to me to explain anything. It is simply a statement that squinting is a mere phenomenon of innervation. This is perhaps true, and is, as Berry says, an extension of Donders' view to its natural conclusion, which is, that squinting arises when the normal relation between the accommodation and convergence is disturbed, or the abnormal situation of the range of accommodation is affected.

TREATMENT.

The kind of strabismus that we have been discussing, convergent, usually associated with anisometropia, with no diminution of the power of the muscles, they moving freely in every direction, is amenable to carefully conducted treatment. When the mobility of the muscle has never been impaired and fixation occurs with one eye only, as obtains in many cases in squint of a marked type in high degrees of astigmatism or hypermetropia, the cases demand a special consideration. But in the typical cases, the course of a surgeon is clear. In case the subject fixes with either eye, and

vision is about the same in each eye, it is well, especially if the squint be not one of more than two lines, to attempt a correction, by the use of correcting glasses. The astigmatism, especially, should be corrected and the glasses worn habitually in all occupations, in case a cure is attempted by this means. It should be persevered in for at least three months, before it is abandoned. This treatment will usually fail. That it does not often succeed is marvellous, when we know, from observation on many cases, that the squint of childhood is frequently outgrown.

In saying it is often outgrown, I mean that we have authentic histories of many cases, where there was marked convergent squint for several years, and when the patient presents himself to the oculist no deformity whatever exists; yet in these cases, what we consider an exciting cause of squint, that is to say, unequal power of vision in the two eyes, with a marked difference in the refraction also, is very often found. Constantly, in studying strabismus, we meet with cases which are not in accord with any exclusive theory as at present understood, and there is no doubt, as was said in the beginning, that much remains to be learned in regard to this subject.

The treatment by atropia is often combined with that with glasses. The atropia is made strong enough, four grains to the ounce, to completely paralyze the accommodation and keep it thus. For this purpose, it is well to instill the solution at first, three times a day, and subsequently when paralysis is well established, once or twice a day. The danger of atropia poisoning, is always to be considered. It is well to apply the solution after eating, also to take great pains not to allow it to enter into the puncta and then into the nose. It is seldom that atropia poisoning is produced by instillations in the eye, but at times it occurs. Hydrobromate of scopolamine is perhaps even more efficient than atropia in paralyzing the accommodation, and may be used in the same manner, but of the strength of one grain to the ounce.

I do not think homatropine compares favorably with atropia or scopolamine, in their effects upon the accommodation. When the squint is a confirmed one, or when the squinting eye is amblyopic, it is very rare indeed that this treatment, of using a mydriatic, has any marked effect, but it ought always to be tried

in the class of cases that I have enumerated, and also in children too young to be subjected to an operation.

An operation will then be resorted to. It is proper to inform the patients, or those responsible for them, that more than one operation may be required; that to have an operation performed for squint, is to enter upon a course of treatment, which may be prolonged for weeks or even months after the operation. With this preliminary understanding, there is no difficulty in maintaining the care of the case, until the final permanent equilibrium of the muscles is obtained. After one operation, the patient is to be carefully observed for some weeks. If, in two or three weeks, it is certain that with glasses a sufficient result has not been attained, the corresponding muscle of the fellow-eye is to be detached and the same watchfulness observed. Usually two operations are sufficient, and in very many cases one is enough. It is well to be slow in deciding upon a second eye, for an excessive effect is easily produced. When equilibrium is restored, the proper glasses should be constantly worn, both for near and far. In time, many patients will leave them off for the distance, if they do not improve the vision, and some few will be able to exercise their accommodation, for the near even, without producing a squint, and not wear glasses. My present plan in prescribing glasses for strabismic patients, on whom I am about to operate, is to choose the glasses before the operation is performed, so that they may be ready, the moment it is over, to wear them. They can usually be worn within twenty-four hours even if some considerable reaction follows the separation of the muscle.

The after-treatment consists in the application of iced cloths for a few hours. If squint remains, atropia or scopolamine is to be used on the same day, to paralyze the accommodation. This with the operation will often be sufficient to keep the eyes straight. If it be so, it is an indication, not a positive one, however, that a second one will not be needed. This operation is one that may safely be performed at clinics or in the physician's consulting rooms, and the patient allowed to go home. The eye operated upon, should be protected from dirt and strong air by a bandage, which should be removed as soon as the patient has reached home, and not reapplied under ordinary circumstances.

The next day, colored glasses should be worn in the air, but no covering is needed in-doors. Some prudence should be shown as to being in a glare of light, while dusty, smoky, or dirty places should be sedulously avoided, lest infection of the conjunctiva and inflammation of Tenon's capsule occur.

RESULTS OF THE OPERATION.

Although a great deal of doubt has been thrown upon the result of the operation for strabismus by certain writers, I do not share their apprehensions as to a favorable result, in carefully chosen cases. The older operation was unsuccessful because it was supposed that it was simply necessary to divide the muscle, and, as is well known, after Dieffenbach first promulgated it, it was simply looked upon as a division of the muscle, similar to the division of the *tendo Achilles* in club-foot. But in club-foot, the surgeon was very careful to use bandages and splints in order to preserve the position which the division of the tendon allowed the foot to assume. The analogy was forgotten by the surgeons of an early period, and they divided the muscle, looked at the apparent improvement in the condition of things which occurred immediately after the operation, and called the case cured. It was, of course, a mere chance, if any such case was cured, and, worse than this, divergent strabismus very often resulted, and the last condition of that patient was worse than the first. All ophthalmic surgeons of our time, have been called upon to remedy the effects of such operations by fishing up the divided muscle, reuniting it to the globe, and dividing its fellow. We are sometimes obliged to do this in operations performed under our present state of knowledge, where excessive effect is produced, but it is very rare that this occurs with the rules now followed, and when it does it is generally sufficient to separate the external rectus from its attachment, when the excessive effect is overcome. I consider that if the surgeon have complete charge of the cases, be allowed to operate, if necessary, two, three, or four times, and if the rules I have given be followed, success is almost certain. Indeed, I should put it down from my own carefully collated experience, both in private and hospital practice, at as high a percentage, of complete cure of the deformity, as ninety-five. In making this estimate, I include cases

where the surgeon is not allowed to have the complete control, where the second operation has been declined, where patients have wilfully disobeyed injunctions as to cleanliness, wearing glasses, and so forth.

To recapitulate: 1st, the operation for convergent strabismus should not be performed on patients who have not learned to use their eyes in reading and writing and the like—in other words, patients less than six years of age.

2d. The refraction should be carefully estimated with the ophthalmometer and glasses, and, if necessary, a mydriatic, before any operation is attempted.

3d. These glasses should be worn for a few days or weeks, according to circumstances, unless it is thoroughly established that the squint is fixed, and that no periodicity in the excessive convergence occurs.

4th. The operation on the fellow-muscle should not be performed in less than two weeks after the first muscle has been divided.

5th. A mydriatic should be used after the operation for at least ten days, unless sufficient effect to remove the deformity is at once produced. If an effect is produced immediately after the operation by the separation of the muscle, and it disappears in a few days, the mydriatic should again be used in connection with the glasses, or if the glasses alone are sufficient, they should be worn.

6th. Usually glasses will be required for from one to two years both for the distance and near, but in many cases they need only be used for close work after the first year or two. In rare cases, in low degrees of hypermetropia, they need not be used at all.

A great deal has been said about partial tenotomies in some modern writings. I recommend operations only for strabismus producing deformities. In latent squints I perform no operations. In all cases the muscle should be fully separated from its attachments. Partial tenotomies are in my judgment illusory in their effects. Instead of a second separation of the same muscle, the external rectus muscle of the same eye, may be brought forward with good results. I think this operation for an increase in the power of the external rectus is better than

repeated separations of the internal straight muscle, in obstinate cases of convergent squint.

It is somewhat remarkable that the deformity is nevertheless corrected in such a very large percentage of cases, although the operation for convergent strabismus, fails to produce the capability for binocular single vision with glasses. It cannot be, therefore, that the want of binocular single vision is the sole factor in the production of the deviation, for, while we do not generally alter this condition by an operation, yet we remove the squint, or we put the muscles in such a condition that glasses will remove it.

DIVERGENT STRABISMUS.

In divergent strabismus one eye is fixed upon the object, while the other looks away from it—diverges.

This form of deviation of the eyeball, is much less common than convergent strabismus. It is thought to occur chiefly in myopic eyes, unless it be the result of an operation for convergent strabismus where, as is well known, in some instances, in consequence of improper division of the muscle, or inability on the part of the patient to return to the surgeon, divergence takes the place of convergence. Very strong convergence is often required in myopia, and yet may be difficult on account of the shape of the eyeball. The internal recti become overstrained, and one eye deviates outward. Then when the refraction is very different in the two eyes, one being, for example, moderately myopic, and the other excessively so, binocular vision is impossible, and divergence quite frequently occurs. We are now speaking of strabismus divergens dependent upon these conditions, and not upon paralysis, which will be discussed in a subsequent chapter.

Donders[1] was the first author to call attention to the relation between divergent strabismus and myopia, which he thought to be the same as that of convergent strabismus to hypermetropia. But he taught that the divergent strabismus of myopia was due to the distention and altered form of the eyeball, which brings the centre of motion in the myopic eye, "absolutely far-

[1] "Accommodation and Refraction," p. 403.

ther from the posterior surface of the sclerotica than in the emmetropic."

In 22 consecutive cases of divergent strabismus, observed by myself, there was hypermetropia in 6 cases, hypermetropic astigmatism in one, and myopic astigmatism in the other eye in 1 case, compound hyperopic astigmatism in 1, simple hyperopic astigmatism in 4 cases, while myopia existed in 6 cases, myopic astigmatism in 3, mixed astigmatism in 1.

It is rather remarkable in this short series of cases, that there was such a proportion of hypermetropic refraction with insufficiency of the interni. Usually, the proportion of myopia is larger, yet it is not at all rare to find divergence with hypermetropic refraction.

While it remains true, as Donders demonstrated, that weakness of the interni and absolute divergence of the eye, are directly associated with myopia, it is also true that there is a class of cases of divergent strabismus that are associated with hypermetropia. But insufficiency of the interni, rather than a constant divergent squint, is the rule, in the cases of hypermetropia that are associated with this weakened muscular condition. For example, a very neurotic patient, anæmic from a long course of injudicious treatment and improper hygiene, becomes unable to fix her eyes upon any near object for any length of time. This occurs from want of accommodative power, that is to say, weakness of the ciliary muscle, as well as of the interni. This condition may be said to be *intermittent*, for the eyes are usually straight. It is not to be relieved by local measures, but by a long course of treatment directed to the general health, especially that of the nervous system. Some of these patients have no astigmatism whatever, only a moderate degree of hypermetropia. When they have astigmatism, the correction of it will play an important part in relieving the weakness of the muscles. I have seen cases of general disease, Bright's disease of the kidneys, locomotor ataxia, with consequent great weakness of the ocular muscles, that were being treated by prisms, and for which tenotomies were advised. No operation for insufficiency should be undertaken, unless a thorough adjustment of glasses has been accomplished, which fails to relieve the defect. The so-called *muscular asthenopia* of later days is founded on these cases.

Graefe's discussions, however, are founded upon cases of insufficiency occurring with myopic refraction. This great observer never went to the lengths of some modern writers, who seem to consider the action of the ocular muscles as independent of the shape of the eyeball, the corneal or axial refraction, or the general muscular ability of the subject who is being tested.

It is very often sufficient in intermittent divergent strabismus, occurring in connection with hypermetropia or hypermetropic astigmatism, to adjust the proper glasses, and limit the amount of work required of the eyes for a time, in order to bring back permanent equilibrium. Neurotic women, and those suffering from uterine disease, having a hypermetropic conformation of the eyeball, sometimes suffer from periodic insufficiency of the interni, which is relieved when the general condition is improved, or when the disease is recovered from. Uterine irritation is a prolific source of inability to continue to use the eyes, an inability which sometimes cannot at all be relieved by even the most careful adjustment of glasses, when there is a decided error of refraction. When there is no marked error, glasses do no good whatever.

The treatment for marked and constant divergent squint, dependent on a refractive condition, is naturally to separate the opposite muscle, the external rectus, from its attachment, with the hope of weakening it so much that the equilibrium may be restored if the proper glasses be worn. This cannot, however, always be accomplished, and the fellow-muscle of the opposite eye must also be separated, so as to increase the effect, and, if this fail, the internal rectus muscle must be brought forward. These operations have already been described in the appropriate chapter.

Where divergent squint is intermittent, and we have simply great insufficiency of the interni, an operation is also justified, in case the patient is more than twelve years of age, and if very great asthenopia or if double vision occur, which cannot be relieved by the adjustment of the proper glasses.

Operations for divergent strabismus, except for those cases arising from an excessive effect from a previous operation for convergent squint, are not so uniformly successful as those for convergent strabismus. In fixed paralytic divergent strabismus they are often unsuccessful.

Divergent squint resulting from excessive effect of operations for convergent strabismus, is not so difficult to manage as that resulting from myopia, and can generally be corrected by division of both externi, and by searching for, bringing up, and reattaching the once separated internal rectus. Operations for this purpose have also been described in the appropriate chapter. It may be said in general terms, that insufficency of the interni, and divergent squint, are more frequently associated with hypermetropia, than Graefe and Donders seem to have thought, and that they are more amenable to treatment than the forms connected with myopic refraction.

STRABISMUS DEORSUM VERGENS (contraction from *de-vorsum*, turned down) AND SURSUM VERGENS (opposite of *deorsum vergens*, upward).

There may be an upward squint, strabismus sursum vergens, and a downward squint, strabismus deorsum vergens. In very rare cases, the upward squint may follow an operation for convergent strabismus. It may be necessary here, in these rare cases, to perform operations on the superior or inferior rectus. The same principles of operation hold good here, as in the more common forms of convergent and divergent strabismus.

CHAPTER XXXIII.

PARALYSIS OF THE MUSCLES OF THE EYE. NYSTAGMUS.

Paralysis may be Partial or Complete.—Paralytic Strabismus.—Causes of Paralysis of Ocular Muscles.—Graefe's Percentage.—Dr. Emerson's Tables.—The Author's.—Paralysis of the Iris.—Ptosis.—Paralysis of the Seventh.—The Diplopia in Paralysis.—The Third Nerve, Recurrent Paralysis of.—The Sixth.—The Fourth.—Ophthalmoplegia—Nystagmus.

Paralysis of the motor nerves of the eyeball may occur partially or completely. For example, the branch of the third nerve, supplying the elevator of the upper lid, may be alone affected, or it may be paralyzed in conjunction with that supplying the internal rectus and the pupil. Again the sixth nerve, supplying the external rectus, may alone be paralyzed, and so on, in as many varieties as the nerve supply of the muscles allows. The nerves may be completely or partially deprived of power. The paralysis may be complete or partial. It is customary to speak of partial paralysis as paresis, although there is no essential difference between paresis and paralysis, except in the completeness of the affection of the muscle. A paralysis of the external muscles, may be very evident to ordinary observation and result in a fixed squint, or it may be so slight as not to be discovered by any appearance of the eye. The patient himself, however, always knows which eye is affected. It is by the patient's aid and by locating the character of the double vision in these cases of paralysis of the external muscles, that we determine which nerves are affected.

The causes of paralysis are very often obscure. It may come from pressure on the nerve, from local inflammation (neuritis), from cerebral or orbital diseases, from syphilis or rheumatism, or a gouty diathesis. Paralysis of certain muscles may result from an exposure to a strong draft of air. A paralytic squint is entirely different from the strabismus that has been

discussed in the preceding chapter, from the fact that the secondary deviation is greater than the primary, instead of being equal to it as it is in strabismus. This is because the deficient innervation of the paralyzed muscle demands a greater effort than is normal to bring the eye into a given position, and this being reflected upon the healthy muscle of the other eye, causes a disproportionate secondary deviation. The most frequent paralyses of the ocular muscles are of those supplied by the third and the sixth cerebral nerves.

SYPHILIS AS A CAUSE OF PARALYSIS.

It is quite generally assumed that paralyses of the ocular muscles are dependent upon syphilis in half the cases. This depends on the statements of Graefe in 1858.

Dr. J. B. Emerson, 1886,[1] made an examination of all the cases of paresis of the ocular muscle that had been seen by himself and myself, for three years. There were 36 cases of paresis of the third nerve, 23 cases of paresis of the sixth nerve, 3 cases of paresis of the fourth nerve, 2 cases of ophthalmoplegia externa; a total of 64 cases. Eighteen of these had a history of syphilis. In 28 there was some other known cause, and in 8 the cause was unknown. This gives a percentage of 28 with specific history, and if we consider, as Dr. Emerson says, the unknown cases to have been syphilitic, a percentage of 56. Of the 64 cases, 44 were males and 20 females. Of the 44 males, 16 had a specific history, and in 10 the cause was unknown. This is a percentage of 36.3 for males, or, if we assume the 10 unknown cases due to syphilis, a percentage of 29. Of the 20 females, 2 had a specific history, and in 8 the cause was unknown. This is a percentage of 10 for the females, or, if we add the unknown cases, a percentage of 50. Both of the cases of ophthalmoplegia externa, one occurring in a boy of nineteen and the other in a man of thirty, were bilateral. There was no specific history in either case, and they did not improve when placed under treatment by mercury and iodide of potassium. One of the cases of paresis of the sixth nerve, was in a woman of sixty-three, who said she was struck by lightning when she was five years of age. Her eyes had turned in ever since.

[1] Quarterly Bulletin, Post-Graduate Medical School, p. 336.

Dr. Emerson remarks that to obtain the high percentage claimed by Von Graefe and others, of syphilis as a cause, we are compelled to attribute to this all cases in which we can find no cause for the paralysis. This he hardly thinks justifiable, and I agree with him that it is not just to do so positively. But, judging from the number of cases of syphilis in persons who are not aware of the fact, who are too ignorant to describe their symptoms, or from whom the real disease has been deliberately concealed by their physician or others, for proper reasons, so that they are actually unaware that they have ever had the disease, and because also these lesions of the nerves are the late lesions of syphilis, I am inclined to the opinion that Graefe's percentage is not too high. I have, however, compiled another table, herewith presented, of all the recorded cases of paralyses seen by myself in private practice. They substantiate this view.

The following table gives the statistics of one hundred and thirteen cases of paralyses.

TABLE SHOWING AGES AND PROBABLE CAUSES OF 113 CASES OF OCULAR PARALYSIS.—MALES, 79; FEMALES, 34.

Ages.		
Under 10 years	5	cases
10 to 20 "	5	"
20 " 30 "	17	"
30 " 40 "	34	"
40 " 50 "	20	"
50 " 60 "	13	"
60 " 70 "	4	"
70 " 80 "	3	"
Age not given	12	"
	113	cases

Paralysis of third nerve involved in 80 cases; internal rectus, 19; superior rectus, 4.

" inferior rectus, 2; pupillary branch, 20; levator (ptosis), 4.

" superior and inferior, 1; superior and internal, 2.

" internal and levator, 4; superior and levator, 1.

" internal and pupillary, 3; internal, levator, and pupillary, 2.

Paralysis of internal rectus, inferior, and levator, 1.
" third and fourth, 1; third and fifth, 2; third and sixth, 6.
" fourth, 2; fifth, 1; sixth, 27; seventh, 3.
" fourth in 3, fifth in 3.
" sixth in 33 and seventh in 3.

There was a history of syphilis or probable syphilis, in 32 cases: rheumatism, 8; traumatism, 7; after operation, 3; anæmia, 2; overwork, 2; tobacco in excess, 2; congenital, 2; neuralgia, 2; kidney disease, 2; diphtheria, 2; cataract, 2.

Locomotor ataxia, meningitis, paralysis agitans, gout, grip, chills and fever, indigestion, uterine disease and intracranial disease, each 1 case, and others where no probable cause could be made out.

These statistics, like those of Emerson, do not positively indicate syphilis as playing so large a part in the causation of paralysis as is ascribed to it by Graefe, but it may be repeated that Graefe's conclusions are probably correct.

TREATMENT.

The treatment, of course, must be directed to the cause. If the paralysis be syphilitic in origin, there is often a promise of relief or cure, but if it be from other causes, the prognosis is, unfortunately, not so good. In the rheumatic paralyses the alkaline treatment is of service, but it is very difficult always to determine just which they are. The cases of traumatic origin need no especial mention, neither those depending upon tumors. The advance in surgery of the brain, may finally lead to a better prognosis in some of these cases, but, as a whole, we can only look upon paresis of the ocular muscles, not dependent upon syphilis or traumatism or rheumatic affections, as being a matter of the gravest importance, and usually requiring the most serious prognosis.

We may have ptosis, divergent squint, and dilatation of the pupil in one subject. The onset of a paralysis of this kind is usually gradual; the patient notices a little inability to move the lid, then there is a kind of halo around the light, and, finally, distinct double vision. All objects, near and far, in decided paralysis of the internal rectus, are seen double. It is by

the character of the double images that the paralysis may be determined when the internal rectus is alone affected. If it exist in conjunction with the other muscles, the diagnosis may be made even before the double images are made out. These double images are crossed. Considerable confusion exists in the minds of beginners as to the origin of crossed and homonymous diplopia. Diplopia has already been discussed, but at this point it may be well to recapitulate. Crossed diplopia may be expected when the muscles supplied by the third nerve are affected, and homonymous diplopia when the single muscles, that is to say, the fourth and sixth, are affected. A good way of fixing these facts in one's understanding is the following: When the internal rectus is paralyzed, of course, the eyeball turns outward. In this turning outward of the eyeball, the macula lutea is turned inward. On an instant's reflection, it will be seen that the projection from that image would be across the line cf the one on the macula holding its true position—hence, the crossed diplopia. In paralysis of the external rectus, on the other hand, the eyeball turns inward and the macula outward, and the line drawn from the macula lutea outward would never meet that drawn from the other macula lutea; hence, we have the false image on the same side with the affected muscle. The tests are very simply made with a lighted candle and a red glass covering one eye, the patient being told to state on which side the red image is. Cases of very slight paralysis, where the eye cannot see that they exist, are most troublesome to the patient, for the simple reason that the displacement of the macula is so slight that the false image falls very near it on a very sensitive part of the retina, and cannot easily be gotten rid of, while, when the paralysis is great, the patient, in time, may suppress the false image. Paralysis of the internal rectus, as was intimated above in the description of the paralysis of the levator, is usually the result of either syphilis or rheumatism, traumatic causes being, of course, excluded. It may also be a symptom of beginning locomotor ataxia. Then, however, it is more apt to be associated with general weakness of the various muscles of the eyeball. When the paralysis is marked, the eye is easily seen to lag behind, when an attempt is made to use both muscles in the same direction. The patients,

themselves, never have any difficulty in determining which muscle is paralyzed, and their statements are usually, if not always, correct.

Insufficiency or partial paresis of the internal rectus, has already been discussed in the chapter on Strabismus, and we need hardly say more here, except that patients with actual paralysis do not usually suffer from asthenopia, for the reason that they use but one eye for close work, as they cannot secure binocular single vision. This kind of paresis is not usually caused by any lesion of the nerve trunk or of the nerve at its origin, at least by any lesion that can be made out, although all insufficiencies, paresis and strabismus, in a certain sense, may be said to be of central origin. But this form of paresis depends, proximately, at least, and perhaps ultimately, on fixed conditions of the eyeball—such a conformation or such errors of refraction, or such a difference in visual power, as render it impossible for the patients to use two eyes at the same time. The treatment of paralysis of the internal rectus, due to lesions in its course or origin, is to be directed toward the cause. Operations for their relief, when they become permanent, are scarcely ever attended with success. Sometimes some effect is produced which improves the condition of the patient, but each case must be studied by itself, and the possibilities of cure, determined by exact observation and prognosis.

PARALYSIS OF THE IRIS.

For the sake of completeness in discussing this subject, certain paralyses of the iris will be considered, although they have been already incidentally mentioned in various places.

Mydriasis (μυδος, moisture; because increase of fluids causes the pupil to dilate), dilatation of the pupil.—The chief causes of this symptom are increased tension of the eyeball, paralysis of the pupillary branch of the third nerve, irritation of the sympathetic nerve, disease of the optic nerve and brain, and the action of certain drugs, such as belladonna, hyoscyamus, stramonium, and so forth. Mydriasis is generally confined to one eye, when it exists as a symptom of disease of the nerve or brain, but both pupils are usually affected when drugs have been taken internally, which have produced it. When mydriasis is not

caused by drugs, the pupil is not dilated to its maximum degree, and is very sluggish in its action. There are very puzzling cases of monocular mydriasis where no cause can be detected.

Myosis (μύω, to close), contraction of the pupil.—This is caused by an irritation of the branch of the third nerve supplying the sphincter pupillæ, by paralysis of sympathetic filaments to the dilator of the pupil. It occurs in certain diseases of the spine, and is said to be produced by constant work at minute objects, as in watch-making, and by certain drugs, such as calabar bean, opium, and so forth.

Hippus (ἵππος, horse).—This is a chronic spasm of the iris causing rapid, alternating contraction and dilatation of pupil, independent of stimulus of light. It is generally associated with nystagmus.

Iridodonesis, or Tremulous Iris (ἶρις, and δονέω, to tremble).—This is marked by trembling of iris when the eye is moved about. It is caused by loss of support of the crystalline lens from whatever cause. It is a symptom which is seen in the absence or dislocation of the lens, and softening of the vitreous, or anything that causes the iris to lose the support of the crystalline lens.

FIG. 177.—CONGENITAL DOUBLE PTOSIS.

PARALYSIS OF THE LEVATOR PALPEBRÆ—PTOSIS.

This is often congenital, and although several operations have been suggested, nothing but partial relief has ever been afforded by any of them. Neither is medical treatment of any avail in the congenital form.

Ptosis occurring in connection with other paralyses in adult or middle life is usually, if treated at all early in its course, very susceptible of cure. It is caused by syphilis or rheumatism, or may be

traumatic. It has been stated already that syphilis forms a large contingent of the causes of paralyses of the muscles of the eyeball. It does not enter largely, however, as a factor into paralysis of the facial, which will shortly be described. The inability to move the upper lid freely is the chief and only symptom of ptosis, and is at once noted by even the most super-

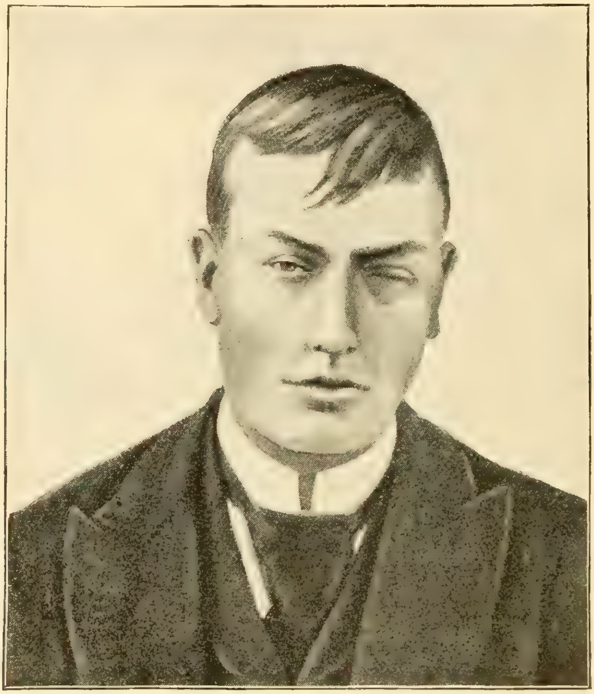

FIG. 178.—PTOSIS OF ONE SIDE.

ficial observer. The accompanying illustrations show first a case of congenital ptosis, complicated with epicanthus, and then a case of ptosis of one eye. In ptosis of a rheumatic origin, the alkaline treatment has been very serviceable in my hands. I generally give the iodide of potassium and salicylate of sodium, not combining the remedies, but alternately using them, at the same time giving Vichy—Saratoga Vichy or foreign Vichy—and Buffalo lithia or other alkaline waters, with great attention to general hygiene. In ptosis from syphilis, prompt treatment is,

I believe, of great avail, for if the lesion is left to itself, to its spontaneous recovery, the nerve is so injured that the paralysis remains, while I think there is no doubt that mercury and iodide of potassium remove the morbid deposits, if promptly used. For all syphilitic affections of the eyeball, I am in the habit of using Squibb's oleate of mercury by inunction, twenty per cent, and, at the same time, the iodide of potassium in increasing doses, always avoiding any poisoning from the iodide or the mercury; that is to say, being on the lookout for coryza, eruptions of the skin, soreness of the gums, and so forth, using the remedy, if possible, so as to avoid any action through these channels, but entirely through the absorbents. If carefully used, patients may take these remedies for weeks without the slightest uncomfortable conditions. The iodide of potassium is to be given largely diluted and usually in Vichy water or milk, as the patient may prefer. In addition to the inunction treatment, mercurial vapor baths, using calomel as a means of procuring the vapor, are very serviceable.

OPERATIONS FOR PTOSIS.

Operative interference in this condition has not generally proved successful. This is, in the very nature of things, to be expected, for the condition is one of paralysis, and ordinary plastic operations have no effect. The operation that I have performed, with only moderate success, has been that of deep sutures entered just above the ciliary margin of the lids, passing through the conjunctiva and muscle, up into the occipito-frontalis, and then being tightly ligated. Sometimes a little effect is produced by such an operation, but it is usually not great. Excision of a portion of the skin can be combined with this method, or the excision may be practised alone, but it is only of service where the skin is very lax and superabundant.

Another operation is to pass the end of a thread below the skin from just above the upper border of the tarsus, to a few millimetres above the eyebrow. The other end is carried in a similar manner, parallel with the first. Similarly situated loops are introduced to either side of this one; these are then all knotted tightly over pieces of drainage-tubing, the lid being

thus raised to an extent rather greater than it is desired to permanently obtain. The knots are tightened above from time to time, until the threads have ulcerated their way through the tracks along which they were passed. It is said to be rather a severe operation, and is followed by great swelling. It is known as Demmet's thread operation.

Panas' operation is one somewhat in vogue, and is performed as follows: An assistant applies his hand to the patient's forehead to prevent the drawing down of the skin of the lid. An ncision is then made along the line of the upper border of the tarsus. It is not continued along the whole line, but beginning immediately over one canthus, and leaving a central portion of a third of an inch uncut, it ends at a similar point above the other canthus. A second horizontal incision, with a slight convexity upward, and not quite an inch in length, is made in the position of the fold separating the eyebrow and lid, and, therefore, just above the orbital margin. This incision passes through all the tissues down to the periosteum. It is then joined, by means of two short vertical incisions, with the inner extremity of the external portion and the outer extremity of the internal portion of the lower incision. Still another incision is made, parallel to the second, somewhat more than one inch in length, along the upper border of the eyebrow, also deep enough to extend to the periosteum. The skin marked out by the middle and lower horizontal, and the two vertical incisions, is next dissected free from the tarsus down to the ciliary border. The bridge between the middle and upper incisions is then undermined, in doing which any wounding of the periosteum or suspensory ligament should be avoided. When this has been done, the dissected flap is pressed up underneath the undermined bridge, and attached by three sutures to the upper edge of the upper incision. The advantage of this operation is that it raises up the tarsal portion of the lid, and, at the same time, causes the occipito-frontalis muscle to act for the absent or paralyzed levator. Berry [1] speaks well of the efficiency of this operation.

[1] "Text-Book," p. 662 *et seq.*

PARALYSIS OF THE FACIAL.

Paralysis of the facial nerve, the seventh, involves the eyelid by causing an inability on the part of the patient to completely close the eye. This is, of course, in conjunction with the other symptoms of facial paralysis. The cheek hangs to one side, the patient is unable to whistle or to shut the eyes. This disease is associated with so many various conditions, that it is impossible to say which is the predominant factor in the greatest number of cases in producing such a paralysis. The lesions that produce it may be central, nuclear, meningeal, or peripheric.[1] When central, it is generally an accompaniment of hemiplegia, and is due to various causes of that form of paralysis. Paralysis of nuclear origin is very rare, and is an accompaniment of glosso-labial palsy, the diphtheritic paralysis, or of a lesion of the pons Varolii. When of meningeal origin, it is due to tumors, meningitis, or fracture of the base of the brain, and is accompanied by disease of other cranial nerves. But the peripheric facial palsy (Bell's paralysis) is the form of the disease which most frequently comes under the notice of the ophthalmologist. Rheumatic influences are here of the most importance in causation. Hutchinson says that syphilis rarely causes an isolated facial paralysis —that "it is apt to leave this nerve alone." And this is my experience, although I have seen paralysis of the seventh caused by syphilis, in conjunction with other paralyses.

The disease needs no particular description at this point. It is chiefly considered by the ophthalmologist, from the inability to close the eye, caused by it. This sometimes produces disease of the cornea from its exposure. In confirmed cases, a plastic operation may be of some service in assisting to cover the lid, but facial paralysis is usually recovered from, although very often not absolutely, that is to say, we may see a trace of it when the eyes are tightly closed or when the lips are puckered.

Facial paralysis, it ought to be stated, like accommodative paralysis, sometimes is a result of diseased teeth, and the removal or proper treatment of the teeth will very often lead to a recovery. Electricity is a remedy which is of some value

[1] Dana: "Text-Book of Nervous Diseases," New York, 1892, p. 134.

in treating the paralyses of the eyelids. It probably acts by keeping up the tone of the muscles until the cause of the disease is removed.

Paralysis of the Superior Rectus.—In this, the movements of the eye upward are restricted, principally when it is turned outward. The double vision usually exists in the upper part of the field of fixation only. The diplopia here also may be sometimes homonymous, when the eye is displaced in the direction of the antagonizing muscles.

Paralysis of the Inferior Oblique.—The movements of the eye are restricted upward, especially when it is at the same time turned inward. Double vision, unless the muscles which move the eye downward preponderate very much, is homonymous and vertical.

Paralysis of Accommodation.—The pupil may be dilated as a result of paralysis of the pupillary branch of the third nerve, in conjunction with paralysis of the other branches, but it may exist as a symptom by itself, mydriasis, as it is called, or dilatation of the pupil. It may have the causes which have been enumerated for the other paralyses, but I have seen marked instances of paralysis of accommodation from disease of the canine teeth. There is a class of cases in which it occurs, very hard to explain, where it exists as a solitary symptom, year after year, without any appreciable disease of the general system or of part of the body.

Recurrent Paralysis of the Third Nerve.—Recurrent paralysis of this nerve was observed in a very remarkable case which I saw with Dr. D. R. Ambrose. In this case, it occurred in the beginning as migraine, that is to say, there would be divergent squint, dilatation of the pupil, partial ptosis, in connection with megrim. These attacks began when the patient was a very young boy, and they continued until the paralysis became permanent, but at first it was only recurrent. I had the privilege of seeing this patient some twenty years after I first saw him. He never secured anything but temporary relief. The paralysis remained as it was in the worst of the early attacks. The attacks of pain were not so frequent, but he took morphia regularly for them, and although engaged in active business, married and having one child, it was apparent he was a very

irritable, so-called "nervous" subject. This opinion his wife confirmed. His child was an incurable choreic patient. The exact lesion which caused this trouble certainly has not been, as yet, determined. Dr. F. L. Jack[1] reports a case having some of the same characteristics, and collects others from 1860 down. The point of chief interest in these cases, as Dr. Jack says, is whether they are functional or organic. That there is a lesion of some kind, I have no doubt, and in that sense, they are not functional, but it must be that the lesion is one that can be increased from time to time, something like a circulatory disturbance. The autopsies, in one case, showed an exudation around the right third nerve along the base of the brain, and a large blood-clot in the pons. Another case died of phthisis. In this, the third nerve was covered with numerous granulations which contained the tubercle bacilli. The third case, the patient died insane. The right motor oculi was gray and club-shaped where it passed through the dura mater. A fibro-chondroma had separated the fibres of the nerve, but had not destroyed them.[2]

Of my case, I think the patient is advancing slowly to a permanent condition of complete paralysis of the internal rectus, and of the pupil.

Paralysis of the External Rectus (Sixth Nerve).—This is one of the most frequent of the single paralyses of the eyeball. It is characterized by convergent squint and homonymous diplopia. It is usually produced, as is paralysis of the internal rectus, when of non-traumatic origin, by syphilis or rheumatism. The prognosis is fairly good.

Paralysis of the Superior Oblique Muscle or Fourth Nerve.—In this paralysis the eyeball moves less readily downward. This is most marked when the eye is directed inward. The double vision is homonymous and vertical. It exists only in the lower half of the eye. I have seen it thus occur in anæmic and neurotic young women and young men.

It is not always easy to say whether a given case of ocular paresis or paralysis is due to peripheric or central causes. Peri-

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[1] Boston Medical and Surgical Journal, vol. 129, p. 617.

[2] For a full account of recurrent paralysis of the motor oculi, see Transactions of the Ophthalmological Society, 1887, p. 460 *et seq.*

pheric lesions may be situated within the orbit or upon the track of the nerve itself, while central lesions may be at the base of the brain, and directly or indirectly involve the nuclei of the third, fourth, and sixth nerves, which all lie within a space of about one inch long by three-quarters of an inch broad at the base of the fourth ventricle and aqueduct of Sylvius. A paralysis of the sixth nerve alone, or of the fourth, is pretty sure to be of peripheric origin, showing that the cause lies in the orbit. It is a little more difficult to determine, in the case of the third nerve, whether the paralysis is central or peripheric, but the more complete it is, the more likely it is to be peripheric. Rheumatic paralysis, or that due to a draft of air, is almost always peripheric.

OPHTHALMOPLEGIA.

(ὀφθαλμος, and πληγη, a stroke.)

Ophthalmoplegia is conveniently divided into total ophthalmoplegia, external ophthalmoplegia, and internal ophthalmoplegia. Total ophthalmoplegia consists in paralysis of the levator muscle of the lid, of all the muscles of the eyeball, and also of the iris and the ciliary muscle. This is the rarest form. The most frequent form is the second, ophthalmoplegia externa, where the outer muscles are paralyzed, and the muscles of accommodation and of the iris remain unimpaired.

The picture of ophthalmoplegia is a very striking one. There is inability to lift the lid, more or less complete ptosis, and almost absolute immobility of the eyeball. It cannot be moved in any direction. There are variations in the degree of this paralysis —the patient may be able to move his eye a little downward, or a little to one side or the other, but there may be complete fixity. If we add to that the paresis of accommodation and mydriasis, we have a most helpless condition, as regards any movement of the eyeball, or of its interior muscles. Ophthalmoplegia interna, where the iris and the ciliary muscles alone are paralyzed, is the rarest.

Causes.—Attempts are made to explain the etiology of ophthalmoplegia according to its completeness or incompleteness. But I doubt if this can be considered a proper method of reasoning. Ophthalmoplegia externa, however, affecting only the

outer muscles, may, according to most authorities, be explained by the situation of the nerve nuclei under the aqueduct of Sylvius. The nuclei for the sphincter pupillæ of the ciliary muscle lie the farthest forward, and are, therefore, frequently unharmed by disease which affects the nuclei of the remaining ocular muscles farther back. This form of ophthalmoplegia, for this reason, can only be of central origin. Ophthalmoplegia interna can be produced, and is produced, by the use of atropine. Complete paralysis (ophthalmoplegia), when dependent on nuclear disease, first affects one muscle, then gradually spreads over the others. The surgeon does not frequently see the beginning of the trouble, and it is only when it has become advanced that it comes to his observation. When total ophthalmoplegia exists, and all the muscles, without exception, are paralyzed, the situation of the lesion may be various. We may have nuclear paralysis, or we may have a lesion of the nerve trunk at the base of the brain, or even within the orbital fissure. It is supposed that most of the cases of ophthalmoplegia depend on a primary disease of the gray matter of the nuclei of the eye muscles. It is analogous in its nature to bulbar paralysis attacking the motor nuclei of the facial, glosso-pharyngeal, hypoglossal, and accessory vagus, which lie farther backward. There are cases, according to Fuchs,[1] where, in advance of the process backward in an ophthalmoplegia, the symptoms of bulbar paralysis also existed.

Ophthalmoplegia externa is generally bilateral, but it may affect one eye only. I have lately seen such a case in a young woman under the care of Dr. A. E. Davis, where the syphilitic history was distinct, and the evidences of the disease could be detected. She recovered almost completely under the use of mercury and iodide of potassium.

NYSTAGMUS.

Nystagmus (νυσταγμός, *a nodding?*) *is characterized by involuntary, spasmodic oscillations of the eyeball, almost always in both eyes at once, and the motions are generally horizontal.*

Nystagmus may be periodical or continuous. It is some-

[1] "Lehrbuch," p. 614.

times so marked as to be seen at some distance from the eyes of the patients; at other times, the sharpest vision will only detect it on very close examination. It may be increased by general excitement or efforts at accommodation. Vision is generally somewhat confused by it, except when it is of a very low degree, and the patient may improve it by inclining the head in the direction opposite to that in which the eyeballs move. The vision, however, when it is congenital, as is usually the case, may not be so much impaired that the subjects do not pursue occupations requiring close attention, and quite exact vision. For example, I have known bookkeepers and teachers to be affected with this disease. Nystagmus is actually but a symptom. It occurs in connection with so many affections, that it is hard to say any more than that it is a condition of things caused by inability to procure perfect vision by exact fixation. It exists in connection with opacities of the cornea, with great errors of refraction, opacities of the crystalline lens, and where no marked disease can be detected, especially in albinos. It is a disease that occurs among coal-miners (Snell), and is probably caused by strain of accommodation in their attempts, in a poor light, with their heads in a very awkward position, to cut out the coal in the proper places.

I saw one case of nystagmus in an infant, fifteen months old, where no cause was ascertained for some weeks. The child became worse and worse, developing head symptoms, and finally died from what proved to be tumor of the brain.

In one case of albinism, connected with nystagmus, I saw the patient first when she was four years of age. When she grew to be a young woman I was able to measure her corneal astigmatism, which was 3 diopters on one side and $3\frac{1}{2}$ on the other, with the rule. I was able to give her glasses which improved her vision from $\frac{10}{200}$ to $\frac{20}{200}$, and enabled her to read No. 1 Jaeger.

In another girl, who was first seen when she was eight years old, who was not an albino but a blonde, the vision was brought up from $\frac{20}{100}$ to $\frac{20}{50}$ in one eye, and $\frac{20}{70}$ in the other, by a cylinder of $3\frac{1}{2}$ diopters. In this case, while the choroid was thin, the nerve discs were normal in appearance, as to color and capillaries.

In another child, with a high degree of myopia, nystagmus was very marked, and the patient lost one eye, from complete detachment of the retina, during the two years that she was under observation.

Astigmatism of a high degree is very apt to be associated with nystagmus.

The treatment is, of course, according to the cause. Some cases of nystagmus connected with strabismus, are very much improved by the correction of the strabismus. Those associated with high degrees of astigmatism, even if it be irregular, are benefited by an approximate correction of the astigmatism. Dr. Deynard publishes several cases to illustrate this.[1]

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[1] The Post-Graduate, vol. vii.

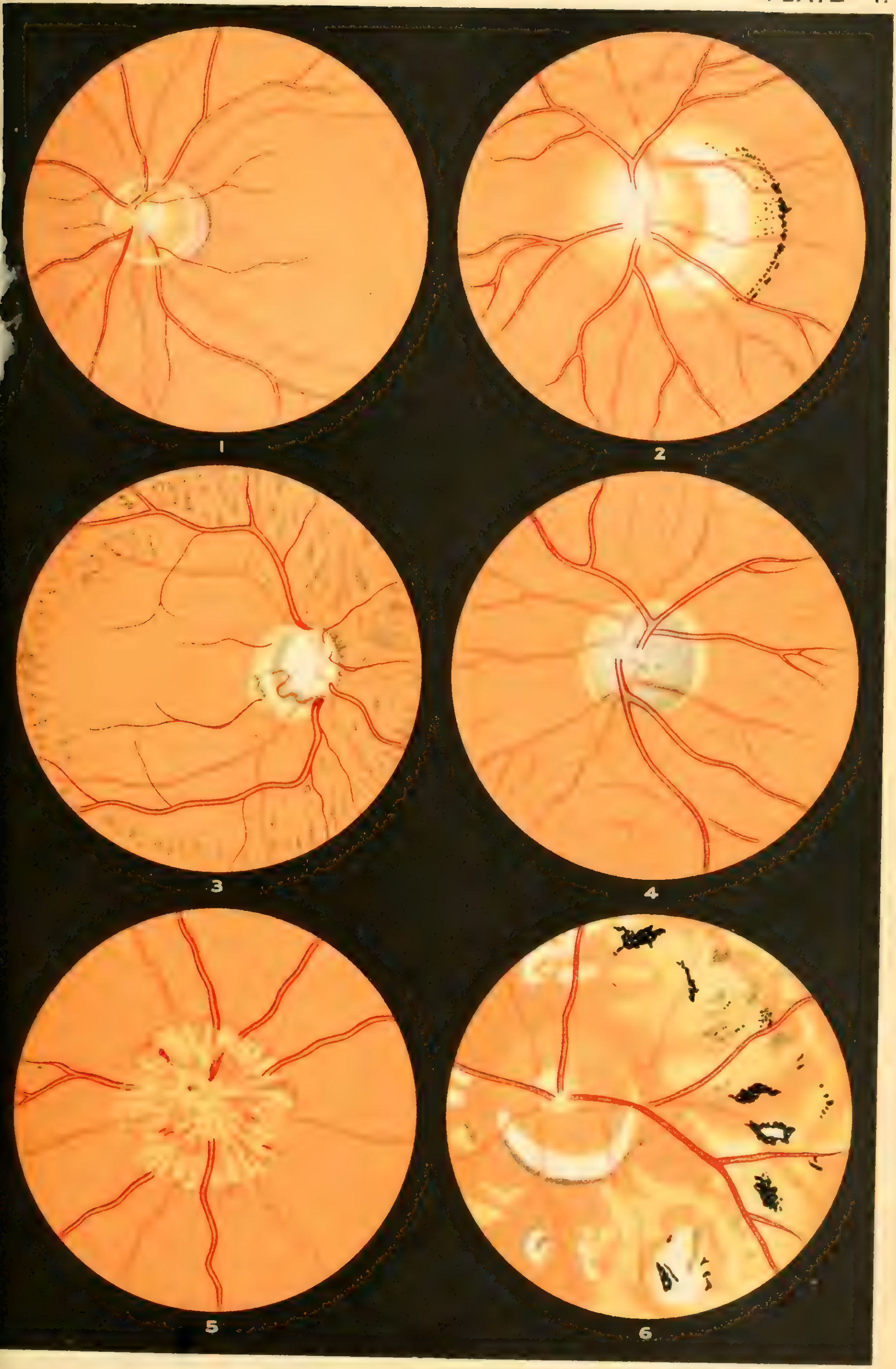
DESCRIPTION OF THE PLATES.

PLATE I.

1. Normal fundus (Stellwag), showing excavation of the optic disc with lamina cribrosa. There is a well-marked scleral ring, and at the temporal side a normal deposit of pigment.
2. Myopia with posterior staphyloma (Schmidt-Rimpler). The optic disc appears large, and at the temporal side is a white crescent-shaped staphyloma with an increased deposit of pigment.
3. Glaucoma in advanced stage (Schmidt-Rimpler). The central part of the optic disc is of clear white color, and at the edge the blood-vessels make a sharp bend.
4. Atrophy of the optic nerve with bluish color of the disc (Schmidt-Rimpler). The blood-vessels are of a larger size than usual in cases of atrophy. The border of the disc is sharply defined and of a white color.
5. Papillitis (Schmidt-Rimpler). The optic disc is greatly swollen, the border being obliterated, and there are small hemorrhages on its surface. The retinal blood-vessels are enlarged and tortuous, and in part covered by the swelling of the disc.
6. Choroiditis (Schmidt-Rimpler). There are numerous spots of partial and some of complete atrophy of the choroid, with pigment. At one point the artery passes into the pigment of the retina and covers choroido-retinitis. There is a whitec rescent at the border of the optic disc.

PLATE II.

7. Retinitis apoplectica (Stellwag). The optic disc is swollen and its outline indistinct. The retinal blood-vessels are tortuous and at different points appear broken. There are numerous extravasations of blood.
8. Retinitis pigmentosa (Stellwag). The optic disc shows white atrophy, the border being sharply defined. The arteries and veins are extremely attenuated. At the periphery are black pigment spots, irregular in shape and similar to bone corpuscles.
9. Retinitis albuminurica (Schmidt-Rimpler). The optic disc is surrounded by large white patches of retinal infiltration and exudation. There are numerous hemorrhages. In the region of the macula and also below, are the characteristic spots of the disease. They are small, white spots of exudation arranged in stellate form.
10. Detachment of the retina below (Stellwag). The lower part of the retina shows a sharply defined area, which is of a greenish-gray color. It represents the retina pushed forward by fluid between it and the choroid. There is an irregular shape and numerous folds, and the retinal vessels are undulating in appearance.
11. Colloid deposits on the optic nerve. Drawn by Miss Elkins from one of the author's cases. The disc appears of a darker color and is covered by small, round, glistening bodies. They appear raised above the surface.
12. Opaque optic-nerve fibres (Miss Elkins). Author's case. This represents the fundus of a case, where this condition was extreme. Around the optic disc and extending into the region of the macula is a white fluffy mass, somewhat striated and covering, except in spots, the retinal blood-vessels.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GLOSSARY.

A

Abduction. Lat. *abductio*, from *ab*, away, and *ducere*, to lead.
Abductor. Lat. *abductor*, from *abduco*, I lead away.
Aberration. Lat. *aberratio*, from *ab*, away, and *errare*, to wander.
Ablation. Lat. *ablatio*, from *aufero*, *ablatum*, to bear away.
Ablepharia. Gr. *a* priv., and *βλέφαρον*, eyelid.
Ablepsia. Gr. *ἀβλεψία*, blindness.
Abscission. Lat. *abscissio*, from *abscidere*, to cut off.
Accommodation. Lat. *accommodatio*, from *accommodare*, to adjust.
Achloropsia. Gr. *a* priv., *χλῶρος*, green, and *ὄψις*, vision.
Achromatic. Gr. *a* priv., and *χρῶμα*, color.
Achromaticity. } Achromatism. } Lat. *achromatismus*, from Gr. *a* priv., and *χρῶμα*, color.
Achromatopsia. } Achromatopsis. } Achromatopsy. } Gr. *a* priv., *χρῶμα*, color, and *ὄψις*, vision.
Achrystallodiaphanie. Gr. *a* priv., *κρύσταλλος*, crystal, and *διαφάνεια*, transparency.
Acritochromacy. Gr. *ἄκριτος*, confused, and *χρῶμα*, color.
Acyanoblepsia. Gr. *a* priv., *κύανος*, blue, and *βλέπειν*, to see.
Adduction. Lat. *adductio*, from *ad*, toward, and *ducere*, to lead.
Adductor. Lat. *adductor*, from *ad*, toward, and *ducere*, to lead.
Advancement. Fr. *avancement*, a bringing forward.
Ægilops. Gr. *αἴξ*, a goat, and *ὤψ*, the eye.
Akyanopsia. Gr. *a* priv., *κυάνος*, blue, and *ὄψις*, vision.
Akyanoblepsia. See Acyanoblepsia.
Albinism. Lat. *albinismus*, from *albus*, white.
Albino. Lat. *albus*, white; Port. and Span. *albino*, white negro.
Albugo. Lat. *albugo*, a white spot.
Amaurosis. Gr. *ἀμαύρωσις*, from *ἀμαυρόω*, to render obscure.
Amblyopia. Gr. *ἀμβλυωπιά*, from *ἀμβλύς*, dull, and *ὄψις*, vision.
Ametrometer. Gr. From Ametropia and *μέτρον*, measure. (Literally a measure of a measure.)
Ametropia. Gr. *ἄμετρος*, beyond, and *ὄψις*, vision.
Amotio. Lat. *amotio*, from *amovere*, to move, detach.
Amplitude. Lat. *amplitudo*, width, range. A. *accommodationis*, amplitude of accommodation.
Anæmia retinæ. Gr. *a* priv., *αἷμα*, blood, and Lat. *retina*, from *rete*, a net.
Anæsthesia. Gr. *ἀναισθησία*, from *a* priv., and *αἴσθησις*, perception.

Anchilops. Gr. ἀγχίλωψ, from ἀγχι, near, and ὤψ, the eye.
Anerythropsia. / Anerythropsy. } Gr. *a* priv., ἐρυθρος, red, and ὄψις, sight.
Aniridia. Gr. ἀν or *a* priv., and ἶρις, the iris.
Anisocoria. Gr. *a* priv., ἴσος, equal, and κόρη, the pupil.
Anisometropia. Gr. ἄνισος, unequal, μέτρον, measure, and ὄψις, vision.
Ankyloblepharon. Gr. ἀγκύλη, a loop, and βλέφαρον, eyelid.
Anophthalmia. Gr. *a* priv., and ὀφθαλμός, the eye.
Anophthalmohémie. (Fr.) From Gr. *a* priv., ὀφθαλμός, eye, and αἷμα, blood.
Anophthalmus. See Anophthalmia.
Anopsia, or Anapia. Gr. ἀνά, without, and ὄψις, vision.
Antimetropia. Gr. ἀντί, opposite, μέτρον, a measure, and ὄψις, vision, or ὤψ, the eye.
Antrum. Lat. *antrum*, a cave
Aphakia. Gr. *a* priv., and φακός, the lens.
Apoplexy retinæ. Gr. ἀποπληξία, a stroke, and Lat. *retina*.
Aplanatism. Gr. *a* priv., and πλανᾶν, to wander.
Apochromatic. Gr. ἀπό, away from, and χρῶμα, color.
Aqueous humor. Lat. *aquosus*, aqueous, and *umor* (not *hu*), fluid, liquid.
Arcus senilis. Lat. *arcus*, a bow, and *senilis*, senile.
Arcus tarseus. Lat. *arcus*, a bow, and Gr. ταρσός, a flat surface, hence the lid.
Argamblyopia. Gr. ἀργός, not working, and ἀμβλυωπία, amblyopia.
Argyria. Gr. ἄργυρος, silver.
Arteria centralis retinæ. (Lat.) Central artery of the retina.
Asthenopia. Gr. ἀσθενής, weak, and ὄψις, vision.
Astigmatism. Gr. *a* priv., and στίγμα, a point.
Astigmometer. / Astigmometry. } Gr. *a* priv., στίγμα, a point, and μέτρον, a measure.
Atresia. Gr. ἄτρητος, without an opening, imperforate. A. *pupillæ*, imperforate pupil (*a* priv., and τρῆσις, perforation—Foster).
Axis. Gr. ἄξων, axis.

B

Bathymorphia. Gr. βαθύς, deep, and μορφή, form, shape. (Old form for Myopia.)
Bdellatomy. Gr. βδέλλα, a leech, and τομή, incision. (An old operation of incising a leech when applied so that the blood would run from him while he continued to suck it from patient.)
Biconcave. Lat. *bis*, twofold, and *concavus*, concave.
Bident. Lat. *bidens*, from *bis*, twice, and *dens*, a tooth.
Bifocal. Lat. *bis*, double, and *focus*, a point, focus.
Binocular. Lat. *binocularis*, from *bis*, twofold, and *oculus*, eye.
Binodal. Lat. *bis*, twofold, and *nodus*, a point.
Blenophthalmia. Gr. βλέννα, mucus, and ὀφθαλμία, from ὀφθαλμός, the eye.
Blepharadenes. Gr. βλέφαρον, eyelid, and ἀδήν, a gland.
Blepharadenitis. Gr. βλέφαρον, eyelid, ἀδήν, a gland, and *itis*, denoting inflammation.
Blepharanthracosis. Gr. βλέφαρον, eyelid, and ἀνθράκωσις, ulcer.
Blephareccopeus. Gr. βλέφαρον, eyelid, and ἐκκοπεύς, a knife for cutting out.

Blepharelosis. Gr. βλέφαρον, eyelid, and εἰλεῖν, to shut.
Blepharemphysema. Gr. βλέφαρον, eyelid, and ἐμφύσημα, inflation.
Blepharis. Gr. βλεφαρίς, eyelash.
Blepharismus. Gr. βλεφαρίζειν, to wink.
Blepharitis. Gr. βλέφαρον, eyelid, and *itis*, denoting inflammation.
Blepharo-adenitis. Gr. βλέφαρον, eyelid, ἀδήν, a gland, and *itis*, denoting inflammation.
Blepharo-adenoma. Gr. βλέφαρον, eyelid, ἀδήν, a gland, and ωμα, morbid.
Blepharo-atheroma. See derivation of Blepharon and Atheroma.
Blepharo-blennorrhœa. Gr. βλέφαρον, eyelid, and Blennorrhœa. See derivation above.
Blepharo-carcinoma. Gr. βλέφαρον, eyelid, and καρκίνωμα (καρκίνος), a cancer.
Blepharo catochus. Gr. βλέφαρον, eyelid, and κάτοχος retentive.
Blepharo-chromidrosis. Gr. βλέφαρον, eyelid, χρῶμα, color, and ἱδρώς, sweat.
Blepharo-cleisis. Gr. βλέφαρον, eyelid, and κλεῖσις, closure.
Blepharo-coloboma. Gr. βλέφαρον, eyelid, and κολόβωμα, mutilation.
Blepharo-conjunctivitis. Gr. βλέφαρον, eyelid, and *conjunctivitis* from *conjunctiva* (Lat.), and *itis*, denoting inflammation.
Blepharo-dyschrœa. Gr. βλέφαρον, eyelid, and δύσχροια, bad color.
Blepharœdema. Gr. βλέφαρον, eyelid, and οἴδημα, a swelling.
Blepharo-hæmatidrosis. Gr. βλέφαρον, eyelid, αἷμα, blood, and ἱδροῦν, to sweat.
Blepharo-hyperidrosis. Gr. βλέφαρον, eyelid, ὑπέρ, excessive, and ἱδροῦν, to sweat.
Blepharo-lithiasis, Gr. βλέφαρον, eyelid, and λιθίασις, a calculous affection.
Blepharo-machærion. Gr. βλέφαρον, eyelid, and μαχαίριον, surgeon's knife.
Blepharo-melæne. Gr. βλέφαρον, eyelid, and μελαίνειν, to blacken.
Blepharo-metrum. Gr. βλέφαρον, eyelid, and μέτρον, a measure.
Blepharon. Gr. βλέφαρον, the eyelid.
Blepharoncosis. Gr. βλέφαρον, eyelid, and ὄγχωσις, enlarged.
Blepharoncus. Gr. βλέφαρον, eyelid, and ὄγκος, an enlargement.
Blepharopachynsis. Gr. βλέφαρον, eyelid, and πάχυνσις, thickening.
Blepharophimosis. Gr. βλέφαρον, eyelid, φίμωσις, a narrowing.
Blepharophlegmasia. Gr. βλέφαρον, eyelid, and φλεγμασία, from φλέγω, I inflame.
Blepharophryplastik (Ger.). Gr. βλέφαρον, eyelid, ὀφρύη, the eyebrow, and πλάσσειν, to form.
Blepharophthalmia. Gr. βλέφαρον, eyelid, and ὀφθαλμία, inflammation of
Blepharophthalmitis. the eye.
Blepharophthalmostat. Gr. βλέφαρον, eyelid, ὀφθαλμός, the eye, and στατικός, fixed.
Blepharophtheiriasis. Gr. βλέφαρον, eyelid, and φθειρίασις, lousiness.
Blepharophyma. Gr. βλέφαρον, eyelid and φῦμα, a tumor.
Blepharoplasty (Blepharoplastia, Blepharoplastica, and Blepharoplastice). Gr. βλέφαρον, eyelid, and πλάσσειν, from πλάσσω, to form.
Blepharoplegia. Gr. βλέφαρον, eyelid, and πληγή, a stroke.
Blepharopsalis. Gr. βλέφαρον, eyelid, and ψαλίς, a pair of scissors.
Blepharoptosis. Gr. βλέφαρον, eyelid, and πτῶσις, a falling.
Blepharopyorrhœa. Gr. βλέφαρον, eyelid. πῦον, pus, and ῥεῖν, to flow.
Blepharorrhaphy. Gr. βλέφαρον, eyelid, and ῥαφή, a suture.
Blepharorrhœa. Gr. βλέφαρον, eyelid, and ῥεῖν, to flow.
Blepharospasm. Gr. βλέφαρον, eyelid, and σπασμός, spasm.

Blepharospath. Gr. *βλέφαρον*, eyelid, and *σπάθη*, spatula.
Blepharostat. Gr. *βλέφαρον*, eyelid, and *στατικός*, fixed.
Blepharostenosis. Gr. *βλέφαρον*, eyelid, and *στένωσις*, a contraction, narrowing.
Blepharosymphysis. Gr. *βλέφαρον*, eyelid, and *σύμφυσις*, a growing together.
Blepharosyndesmitis. Gr. *βλέφαρον*, eyelid, and *σύνδεσμος*, a bond, a band.
Blepharosynechia. Gr. *βλέφαρον*, eyelid, and *συνέχεια*, a growing together.
Blepharoxyston. Gr. *βλέφαρον*, eyelid, and *ξύειν* from *ξύω*, to scrape.
Blepharydatis. Gr. *βλέφαρον*, eyelid, and *ὑδατίς*, a watery vesicle.
Blindness. Ger. *Blindheit.* Gr. *τυφλότης.*
Blindsack. Ger. for Cul-de-sac.
Blinken. Ger. for Nystagmus.
Blinkern. Ger. for Nictitation.
Brachymetropia. Gr. *βραχύς*, short, *μέτρον*, measure, and *ὄψις*, vision.
Buphthalmia. } Buphthalmos. } Buphthalmus. } Gr. *βοῦς*, an ox, and *ὀφθαλμός*, eye.

C.

Cacophthalmia. Gr. *κακός*, bad, and *ὀφθαλμία*, ophthalmia.
Canaliculus or Canalicula. Diminutive of *canalis*.
Canalicular. Lat. *canalicularis*, having channels.
Canities or Canita. Lat. *canus*, white.
Canthitis. Lat. *canthitis*, inflammation of the angle of the eyelids.
Cantholysis. Gr. *κανθός*, angle of the eye, and *λύειν*, to loosen.
Canthoplasty. Gr. *κανθός*, angle of the eye, and *πλάσσειν*, to form.
Canthorrhaphy. Gr. *κανθός*, angle of the eye, and *ῥαφή*, a seam.
Canthotomy, or Canthectomy. Gr. *κανθός*, angle of the eye, and *τέμνειν*, to cut.
Canthus. Gr. *κανθός*, angle of the eye.
Capsa. Gr. *κάψα*, a case. See Capsule.
Capsitis. Gr. *κάψα*, a case, and *itis*, denoting inflammation.
Capsocataracta. See Capsa and Cataract.
Capsulatome. Lat. *capsula*, a capsule, and Gr. *τέμνειν*, to cut.
Capsule. Lat. *capsula*, Gr. *καψάκιον*, a sac.
Capsulitis. Lat. *capsula*, a capsule, and *itis*, denoting inflammation.
Capsulo-ciliaris. See Capsule and Ciliary.
Capsulo-pupillary. See Capsule and Pupil.
Capsulotomy. Lat., *capsula*, capsule, and Gr. *τέμνειν*, to cut.
Carcinoma. Gr. *καρκίνομα*, a cancer, from *καρκίνος*, an eating ulcer.
Caruncle. Lat. *caruncula*, diminutive of *caro*, flesh.
Cataract. Lat. *cataracta*. Gr. *καταῤῥάκτης*, from *καταῤῥέω*, to flow down, a cataract.
Cataractocatapiesis. Gr. *καταῤῥάκτης*, a cataract, and *καταπίεσις*, depression.
Cataractocatathesis. Gr. *καταῤῥάκτης*, a cataract, and *κατάθεσις*, depression.
Catopter. Gr. *κατοπτήρ*, a spy (an old name for a speculum).
Catoptrics. Gr. *κατοπτρική* (sub. *τέχνη* or *ἐπιστήμη*) from *κάτοπτρον*, a mirror.
Cellulitis. Lat. *cellula*, a small chamber, and *itis*, denoting inflammation.
Centrad. Lat. *centrum*. Gr. *κέντρον*, the centre.
Chalazacium. } Chalazion. } Gr. *χαλάζιον*, from *χάλαζα*, hail.
Chalaziophyma. Gr. *χαλάζιον*, and *φῦμα*, a growth.

Chalazosis. Gr. χαλάζωσις, hail-like formations.
Chemosis. Gr. χήμωσις, from χήμη, a yawning, or χυμός, juice.
Chiasm.
Chiasma. Gr. χίασμα, a crossing, as the two limbs of the letter χ.
Chlorophane. Gr. χλωρός, green, φαίνεσθαι, to appear.
Chorio-capillaris. Gr. χόριον, skin, and Lat. *capillaris*, capillary.
Choriocele. Gr. χόριον, skin, and κήλη, a tumor.
Choroid. Gr. χοριοειδής, from χόριον, skin, and εἶδος, like.
Choroideremia. Gr. χοριοειδής, skin-like, and ἐρημία, devoid.
Choroiditis. Gr. χόριον, skin, and *itis*, denoting inflammation.
Choroido-cyclitis. Gr. χοριοειδής, skin-like, κύκλος, a circle, and *itis*, denoting inflammation.
Choroido-iritis. Gr. χοριοειδής, skin-like, ἶρις, the rainbow, and *itis*, denoting inflammation.
Choroido-retinitis. Gr. χοριοειδής, skin-like, and Lat. *retina*, from *rete*, a net, and *itis*, denoting inflammation.
Chromasia. Gr. χρῶμα, or χροιά, color.
Chromatelopsis. Gr. χρῶμα, color, ἀτελής, imperfect, and ὄψις, vision.
Chromatics. Gr. χρῶμα, color, and ἐπιστήμη, science.
Chromatidrisis. See Chromidrosis.
Chromatism. Gr. χρωματισμός, coloration.
Chromato-dysopia. Gr. χρῶμα, color, δυς, difficult, and ὄψις, vision.
Chromatography, Chromatology. See Chromatics.
Chromatometablepsia. Gr. χρῶμα, color, μετά, ill, and ὄψις, vision.
Chromatometer.
Chromatometry. Gr. χρῶμα, color, and μέτρον, a measure.
Chromatophobia. Gr. χρῶμα, color, and φόβος, fear.
Chromatopseudoblepsia. Gr. χρῶμα, color, ψευδής, false, and βλέψις, vision.
Chromatopseudopsia. Gr. χρῶμα, color, ψευδής, false, and ὄψις, vision.
Chromatopsia. Gr. χρῶμα, color, and ὄψις, vision.
Chromatoptometer.
Chromatoptometry. Gr. χρῶμα, color, ὀπτεῖν, to see, and μέτρον, a measure.
Chromatoscope.
Chromatoscopy. Gr. χρῶμα, color, and σκοπεῖν, to examine.
Chromatoskiameter. Gr. χρῶμα, color, σκιά, a shadow, and μέτρον, a measure.
Chromidrosis. Gr. χρῶμα, color, and ἱδρωσις, perspiration.
Chromiometer.
Chromometer. See Chromatometer.
Chromophane. Gr. χρῶμα, color, and φαίνεσθαι, to appear.
Chromopia. See Chromatopsia.
Chromopseudopsia.
Chromopseudopsis. Gr. χρωμα, color, ψευδής, false, and ὄψις, vision.
Chromopsia. See Chromatopsia.
Chromoptometer.
Chromoptometry. Gr. χρῶμα, color, ὀπτεύειν, to see, and μέτρον, a measure.
Cilia, *pl.* of Cilium. Lat. *cilium* (literally) an eyelid. Gr. κύλα, an eyelid.
Ciliary. Lat. *ciliaris*, pertaining to the cilia.
Circumcorneal. Lat. *circum*, around, and *cornealis*, corneal.
Circumlentil. Lat. *circum*, around, and *lens*, a lentil.
Cirsoblepharon. Gr. κιρσός, a varix, and βλέφαρον, the eyelid.
Cirsophthalmia. Gr. κιρσός, a varix, and ὀφθαλμία, inflammation of the eye.

Clavus oculi. Lat. *clavus*, a nail, and *oculus*, eye.
Coloboma. Gr. *κολόβωμα*, imperfection.
Commissure. Lat. *commissura*, a joining together, point of union.
Concave. Lat. *concavus*; hollowed out.
Concavo-concave. Lat. *concavo-concavus*. See Biconcave.
Concavo-convex. Lat. *concavo-convexus*, concave one side, and convex other side.
Concentric. Lat. *concentricus*, common to one centre.
Concomitant. Lat. *concomitans*, from *con*, with, and *comitare*, to accompany.
Confusio, Confusion. Lat. *confusio*, from *con*, together, and *fundere*, to pour.
Conical. Gr. *κωνικός*, cone-shaped.
Conjugate. Lat. *conjugatus*, yoked together.
Conjunctiva. Lat. *conjunctivus* (*tunica* understood), from *con*, together and *jungere*, to join.
Conjunctivitis. Lat. *conjunctiva*, from *conjungere*, to join, and *itis*, denoting inflammation.
Conus cornealis. Lat. *conus*, a cone, and *cornealis*, corneal.
Convergence. Lat. *convergentia*, from *convergere*, to incline toward each other.
Convex. Lat. *convexus*, an arched surface the centre of which is higher than the edges.
Convexo-concave. See Concavo-convex.
Convexo-convex. Lat. *convexo-convexus*. See Biconvex.
Convexulus. Lat. dim. from *convexus*, convex.
Co-ordination. Lat. *coordinatio*, harmonious action.
Copiopia. / Copopsia. Gr. *κόπος*, painful, and *ὄψις*, vision.
Coquilles. Fr. *coquille*, a shell. Gr. *κοχλίας*, a spiral shell.
Core. Gr. *κόρη*, the pupil of the eye.
Corectasis. Gr. *κόρη*, the pupil, and *ἔκτασις*, dilatation.
Corectenia. Gr. *κόρη*, the pupil, and *ἐκτένεια*, extension.
Corectodialysis. Gr. *κόρη*, the pupil, and *διάλυσις*, liberation.
Corectomia. Gr. *κόρη*, the pupil, and *ἐκτέμνεν*, to cut out.
Corectomodialysis. See Corectodialysis.
Corectopia. Gr. *κόρη*, the pupil, and *ἔκτοπος*, out of place.
Coredialysis. Gr. *κόρη*, the pupil, and *διάλυσις*, liberation.
Corediastasis. Gr. *κόρη*, the pupil, and *διάστασις*, dilatation.
Corediastole. See Corediastasis.
Corelysis. Gr. *κόρη*, the pupil, and *λύειν*, to loosen.
Coremetamorphosis. Gr. *κόρη*, the pupil, and *μεταμόρφωσις*, a transformation.
Coremetathesis. Gr. *κόρη*, the pupil, and *μετάθεσις*, changing.
Corencleisis. Gr. *κόρη*, the pupil, and *ἐνκλεῖσις*, inclusion.
Coreometer. Gr. *κόρη*, the pupil, and *μέτρον*, a measure.
Coreoncion, Coreoncium. Gr. *κόρη*, the pupil, and *ὄγκος*, a hook.
Corephthisis. Gr. *κόρη*, the pupil, and *φθίσις*, a dwindling.
Coreplasty. Gr. *κόρη*, the pupil, and *πλαστική*, from *πλάσσω*, to form.
Corestenoma. Gr. *κόρη*, the pupil, and *στένωμα*, a narrow place.
Coretodialysis. Gr. *κόρη*, the pupil, and *διάλυσις*, a loosening.
Coretomodialysis. *κόρη*, the pupil, *τέμνειν*, to cut, and *διάλυσις*, a loosening.
Coretomy. Gr. *κόρη*, the pupil, and *τέμνειν*, to cut.

Coretonectomy. Gr. κόρη, the pupil, and ἐκτέμνειν, to cut out.
Coretotomy. Gr. κόρη, the pupil, and τέμνειν, to cut.
Cornea. Lat. *cornu*, a horn.
Corneitis. Lat. *cornea*, from *cornu*, horn, and *itis*, denoting inflammation.
Coromegine. Gr. κόρη, the pupil, and μέγας, large.
Coromeiosis, Coromiosis. Gr. κόρη, the pupil, and μείωσις, diminution.
Coromorphoma. Gr. κόρη, the pupil, and μόρφωμα, a form.
Coromorphosis. Gr. κόρη, the pupil, and μόρφωσις, a forming.
Coromydriasis. See Mydriasis.
Coropareleysis. Gr. κόρη, the pupil, and παρέλκυσις, from παρέλκω, to draw aside.
Cortex. Lat. *cortex*, the bark.
Cortical. Lat. *corticalis*, pertaining to the cortex.
Couch. Fr. *coucher*, to lay down.
Couching. See Reclination.
Cryptophthalmia. / Cryptophthalmus. } Gr. κρυπτός, hidden, and ὀφθαλμός, the eye.
Crystalline. Gr. κρυσταλλοειδής, from κρύσταλλος, crystal, and ειδος, like.
Crystallinocapsulitis. Gr. κρυστάλλινος, from κρύσταλλος, crystal, Lat. *capsula*, capsule, and *itis*, denoting inflammation.
Crystallinocele. Gr. κρυστάλλινος, of crystal, and κήλη, a tumor.
Crystallitis. Gr. κρύσταλλος, crystal, and *itis*, denoting inflammation.
Crystallocatapiesis. Gr. κρύσταλλος, crystal, and καταπίεσις, a pressing down.
Crystallocataracta. Gr. κρύρταλλος, crystal, and καταῤῥάκτης, a cataract.
Crystallocatathesis. Gr. κρύσταλλος, crystal, and κατάθεσις, a putting down.
Crystalloiditis. See Crystallitis.
Crystalloparatopia. Gr. κρύσταλλος, crystal, παρά, aside, and τόπος, a place.
Cul-de-sac. Fr. *cul-de-sac*, a blind alley.
Cyclicotomy. Gr. κυκλικός, circular, and τέμνειν, to cut.
Cyclitis. Gr. κύκλος, a circle, and *itis*, denoting inflammation.
Cyclopanophthalmia. Gr. κύκλωψ, the round-eyed, *α* privative, and ὀφθαλμός, the eye.
Cyclopia. Gr. κυκλώπιος, the round-eyed.
Cycloplegia. Gr. κύκλος, a circle, and πληγή, a stroke, paralysis.
Cyclotome. Gr. κύκλος, a circle, and τέμνειν, to cut.
Cylicotomy. Gr. κύλιξ, a cup, and τέμνειν, to cut.
Cylinder. Gr. κύλινδρος, a cylinder.
Cylindrical. Gr. κυλινδρικός, cyclindrical.
Cylindriform. Gr. κύλινδρος, a cylinder, and Lat. *forma*, shape.
Cysticercus. Gr. κύστις, *a sac*, and κέρκος, a tail.
Cystotome. Gr. κύστις, *a sac*, and τέμνειν, to cut.

D.

Dacryadenalgia. Gr. δάκρυον, a tear, ἀδήν, a gland, and ἄλγος, pain.
Dacryadenitis. Gr. δάκρυον, a tear, ἀδήν, a gland, and *itis*, denoting inflammation.
Dacryadenoscirrhus. Gr. δάκρυον, a tear, ἀδήν, a gland, and σκίρος, hard.
Dacryæmorrhysis. / Dacryhæmorrhysis. } Gr. δάκρυον, a tear, αἷμα, blood, and ῥύσις, a flowing.
Dacryagogatresia. Gr. δάκρυον, a tear, ἀγωγός, guiding, and ἄτρητος, closed.

Dacryagogus. Gr. *δάκρυον*, a tear, and *ἀγωγός*, guiding, conducting.
Dacryallosis. Gr. *δάκρυον*, a tear, and *ἀλλοίωσις*, alteration.
Dacryelcosis. }
Dacryhelcosis. } Gr. *δάκρυον*, a tear, and *ἕλκωσις*, ulceration.
Dacrygelasis. Gr. *δάκρυον*, a tear, and *γέλως*, laughter.
Dacryin. Lat. *dacryinum*, from Gr. *δάκρυον*, a tear.
Dacryma. See Dacryon.
Dacryoblennorrhœa. Gr. *δάκρυον*, a tear, *βλέννα*, mucus, and *ῥεῖν*, to flow.
Dacryocystalgia. Gr. *δάκρυον*, a tear, *κύστις*, a sac, and *ἄλγος*, pain.
Dacryocystatonia. Gr. *δάκρυον*, a tear, *κύστις*, a sac, and *ἀτονία*, slackness.
Dacryocyste. }
Dacryocystis. } Gr. *δάκρυον*, a tear, and *κύστις*, a sac.
Dacryocystitis. Gr. *δάκρυον*, a tear, *κύστις*, a sac, and *itis*, denoting inflammation.
Dacryocystoblennorrhœa. Gr. *δάκρυον*, a tear, *κύστις*, a sac, *βλέννα*, mucus, and *ῥεῖν*, to flow.
Dacryocystoblennostasis. Gr. *δάκρυον*, a tear, *κύστις*, a sac, *βλέννα*, mucus, and *στάσις*, stagnation.
Dacryocystocele. Gr. *δάκρυον*, a tear, *κύστις*, a sac, and *κήλη*, a tumor.
Dacryocystoptosis. }
Dacryoptosis. } Gr. *δάκρυον*, a tear, *κύστις*, a sac, and *πτῶσις*, a falling.
Dacryocystosyringokatakleisis. Gr. *δάκρυον*, a tear, *κύστις*, a sac, *σῦριγξ*, a fistula, and *κατάκλεισις*, a shutting up.
Dacryodes. Gr. *δακρυώδης*, tear-like.
Dacryohæmorrhœa. }
Dacryohæmorrhysis. } See Dacryæmorrhysis.
Dacryoid. Gr. *δακρυώδης*, tear-like.
Dacryolin. Fr. *dacryoline*, from Gr. *δάκρυον*, a tear.
Dacryolite. }
Dacryolith. } Gr. *δάκρυον*, a tear, and *λίθος*, a stone.
Dacryolithiasis. Gr. *δάκρυον*, a tear, and *λιθίασις*, stone formation.
Dacryoma. Gr. *δάκρυον*, a tear, and *ὀμα*, a tumor.
Dacryon. Gr. *δάκρυον*, a tear.
Dacryonome. Gr. *δάκρυον*, a tear, and *νομή*, an eating sore.
Dacryopeus. }
Dacryopoios. } Gr. *δάκρυον*, a tear, and *ποιός*, from *ποιέω*, to produce.
Dacryops. Gr. *δάκρυον*, a tear, and *ὤψ*, the eye.
Dacryopyorrhœa. Gr. *δάκρυον*, a tear, *πύον*, pus, and *ῥεῖν*, to flow.
Dacryosolen. *δάκρυον*, a tear, and *σωλήν*, a canal.
Dacryosolenitis. *δάκρυον*, a tear, and *σωλήν*, a canal, and *itis*, denoting inflammation.
Dacryostagia, }
Dacryostagma, } Gr. *δάκρυον*, a tear, *στάζειν*, from *στάζω*, to drop.
Dacryostagon. }
Dacryosyrinx. Gr. *δάκρυον*, a tear, and *σύριγξ*, a canal.
Dacryrrhœa. }
Dacryrrhysis. } See Dacryorrhœa.
Daltonism. (Lat. *daltonismus*). See Achromatopsia.
Decentered. Lat. *de*, from, and *centrum*, from Gr. *κέντρον*, a centre, point.
Decussation. Lat. *decussatio*, from *decussare*, to cross.
Deorsum vergens. Lat. *deorsum*, downward, and *vergo*, to turn.

Depilation. Lat. *depilatio*, from *depilare*, to pluck out hair.
Descemetitis (word improperly formed.—Dung.). Descemet, and *itis*, denoting inflammation.
Descemetocele. Descemet, and Gr. κήλη, tumor.
Diaptosis. Gr. διάπτωσις, a falling away. See Ptosis.
Dichroism. Dichromatism. } Gr. δίς, twofold, and χρωΐζειν, to color.
Dichromatopsia. Dichromism. } Gr. δίς, twice, χρῶμα, color, and ὄψις, vision.
Dichroscope. Gr. δίχροος, double color, and σκοπεῖν, to see.
Dictyitis. Gr. δίκτυον, a net, and *itis*, denoting inflammation. See Retinitis.
Dictyopsia. Gr. δίκτυον, a net, and ὄψις, vision.
Dictyoschisma. Gr. δίκτυον, a net, and σχίσμα, a cleft.
Dictyosie. Fr. *dictyosie*, from Gr. δικτυόω, to weave like a net.
Dilaceration. Lat. *dilacerare*, to tear apart.
Dilatation. Lat. *dilatatio*, from *dilatare*, to dilate, widen.
Diophthalmus. Gr. δίς, twice, and ὀφθαλμός, the eye.
Diops. Gr. δίς, twice, and ὤψ, the eye.
Diopsimeter. Gr. δίοψις, accurate view of, and μέτρον, a measure.
Diopter. Dioptre. Dioptry. } Gr. διοπτήρ, a spy. See Dioptra.
Dioptometry. Dioptrometry. } Gr. διοπτήρ, a spy, and μέτρον, a measure.
Dioptoscopy. Gr. διοπτήρ, a spy, and σκοπέω, to see.
Dioptra. Gr. δίοπτρα, a spying-tube.
Dioptric. Gr. διοπτρικός, pertaining to the use of the Dioptra.
Dioptrics. Fr. *dioptrique*. (The science of refraction.)
Dioptrismus. Gr. διοπτρισμός, an opening with the Dioptra.
Dioptrion. Dioptron. } Gr. δίοπτρον. See Dioptra.
Diplopia. Diplopsis. } Gr. διπλόος, double, and ὄψις, vision.
Disc. δίσκος, a round plate.
Discission. Lat. *discissio*, from *discindere*, to cut apart.
Distichiasis. Gr. διστιχία, a double row.
Divergence. Divergent. } Lat. *divergens*, from *dis*, apart, and *vergere*, to turn.
Duct. Lat. *ductus*, from *ducere*, to lead.
Dynamic. Gr. δυναμικός, from δύναμις, power.
Dyschromatope. Dyschromatopsia. } Gr. δυς, confused, χρῶμα, color, and ὄψις, vision.
Dyscoria. Gr. δυς, confused, and κόρη, the pupil.
Dysope. Dysopia. Dysopsia. } Gr. δυσωπία, a look of shame.
Dysorasis. Gr. δυς, confused, and ὅρασις, vision.

E.

Ecchymosis. Gr. ἐκχύμωσις, from ἐκ, out, χέειν, to pour.
Ectasia. Ectasis. } Gr. ἔκτασις, a stretching out.

Ectopia.
Ectopie.
Ectopion.
Ectopsis. } Gr. ἔκτοπος, out of place.
Ectopismus.
Ectopium.
Ectopius.
Ectropion. } Gr. ἐκτρόπιον, from ἐκτρέπειν, to turn out.
Ectropium.
Embolism. Gr. ἐμβολισμός, from ἐμβάλλειν, to throw in.
Emmetropia. Gr. ἔμμετρος, according to measure, and ὤψ, the eye.
Encanthis. Gr. ἐγκανθίς, from ἐν, in, and κανθός, corner of the eye.
Endothelium. Gr. ἔνδον, within, and θηλή, a nipple.
Enophthalmia. } Gr. ἐν, in, and ὀφθαλμός, the eye.
Enophthalmus.
Entoptic. Gr. ἐντός, within, and ὀπτικός, optic.
Entoptics. } Gr. ἐντος, within, ὤψ, the eye, and σκοπεῖν, to view.
Entoptoscopy.
Entropion. } Gr. ἐν, in, and τροπή, a turning.
Entropium.
Enucleation. Lat. *enucleare*, to take out the kernel.
Ephidrosis. Gr. ἐφίδρωσις, from ἐπί, upon, and ἱδρως, sweat.
Epiblepharon. Gr. ἐπί, upon, and βλέφαρον, the eyelid. See Epicanthis.
Epicanthis. } Gr. ἐπί, upon, and κανθός, the angle of the eye.
Epicanthus.
Epilation. Lat. *epilatio*, from *e* priv., and *pilus*, a hair.
Epiphora. Gr. ἐπιφορά, from ἐπιφέρω, to bring upon.
Episclera. } Gr. ἐπί, upon and σκληρός, hard.
Episclerotic.
Episcleritis. Gr. ἐπί, upon, σκληρός, *hard*, and *itis*, denoting inflammation.
Episcope. Gr. ἐπί, upon, and σκοπεῖν, to view.
Episcotister. Gr. ἐπισκοτίζειν, to throw a shadow over.
Epithelium. Gr. ἐπί, upon, and θηλή, a nipple.
Erythropia.
Erythrops. } Gr. ἐρυθρός, red, and ὄψις, vision.
Erythropsia.
Erythropsin. See Visual Purple.
Eversion. Lat. *eversio*, a turning outward.
Evisceration. Lat. *evisceratio*, from *ex*, out, and *viscera*, the viscera.
Excision. Lat. *excisio*, from *ex*, out, and *cædere*, to cut.
Exclusion. Lat. *exclusio*, from *excludere*, to shut out.
Exenteration. Gr. ἐξ, out of, and ἔντερα, the entrails.
Exophthalmia.
Exophthalmos. } Gr. ἐξ, out, and ὀφθαλμός, the eye.
Exophthalmus.
Exophthalmometer. Gr. ἐξόφθαλμος, with prominent eyes, and μέτρον, a measure.
Extraction. Lat. *extractio*, from *ex*, out of, and *trahere*, to draw.
Extra-ocular. Lat. *extra-ocularis*, outside the eyes.
Extra-orbital. Lat. *extra-orbitalis*, outside the orbits.
Eye. A-S. *ege*; O. Sax. *oga*; N. H. Ger., *auge*; Gr. ὤψ; Lat. *oculus*.

F.

Facultative. Lat. *facultas*, capability.
Fantoscope. Gr. *φάντασμα*, an image, and *σκοπεῖν*, to view.
Fenestra. Lat. *fenestra*, a window.
Fixation. Lat. *fixatio*, from *figere*, to fasten.
Focus. Lat. *focus*, a hearth.
Foramen. Lat. *foramen*, an opening.
Fornix. Lat. *fornix*, an arch.
Fovea. Lat. *fovea*, a small point.
Fundus. Lat. *fundus*, a bottom.
Fusca. Lat. *fuscus*, dark.

G.

Gerontoxon. Gr. *γέρων*, an old man, and *τόξον*, a bow.
Glaucoma. Gr. *γλαύκωμα*, from *γλαυκός*, green.
Glaucosis. Gr. *γλαύκωσις*, from *γλαυκόομαι*, to blind by glaucoma.
Glioma. Gr. *γλία*, glue.
Goggles. O. Eng., goggle-eyed. Cf. Lat. *cocles*, from Gr. *σκότος*, darkness, and Lat. *oculus*, the eye.
Grando. Lat. *grando*, hail.
Green-blindness. See Achloropsia.

H.

Hæmophthalmia. Gr. *αἷμα*, blood, and *ὀφθαλμία*, a disease of the eyes.
Hæmophthalmus. Gr. *αἷμα*, blood, and *ὀφθαλμός*, the eye.
Hemeralopia. / **Hemeralops.** Gr. *ἡμέρα*, day, and *ὄψις*, vision.
Hemiachromatopsia. Gr. *ἡμι*, half, *α* priv., *χρῶμα*, color, and *ὄψις*, vision.
Hemiopalgia. Gr. *ἡμι*, half, *ὤψ*, the eye, and *ἄλγος*, pain.
Hemiopia. / **Hemiopiasis.** / **Hemiopsia.** / **Hemiopsis.** Gr. *ἡμι*, half, and *ὄψις*, vision.
Heteronymous. Gr. *ἕτερος*, different, and *ὄνυμα*, a name.
Heterophthalmia. Gr. *ἑτεροφθαλμία*, from *ἕτερος*, different, and *ὀφθαλμία*, ophthalmia.
Heterophthalmos. Gr. *ἑτερόφθαλμος*, from *ἕτερος*, different, and *ὀφθαλμός*, the eye.
Hippus. Gr. *ἵππος*, a horse; from twinkling of a man's eyes on horseback (?).
Homocentric. Gr. *ὅμος*, common, and *κέντρον*, a centre.
Homonymous. Gr. *ὁμώνυμος*, from *ὁμός*, one, and *ὄνυμα*, name.
Hordeolum. Lat. dimin. from *hordeum*, barley; or *hordeolus*, a stye.
Horopter. Gr. *ὅρος*, a boundary, and *ὀπτήρ*, one who sees.
Hyalitis. Gr. *ὑαλῖτις*, from *ὕαλος*, glass, and *itis*, denoting inflammation.
Hyaloid. Gr. *ὕαλος*, glass, and *εἶδος*, like.
Hydrophthalmia. Gr. *ὕδωρ*, water, and *ὀφθαλμία*, ophthalmia.
Hydrophthalmion. / **Hydrophthalmium.** Gr. *ὕδωρ*, water, and *ὀφθάλμιον*, a little eye.
Hydrophthalmos. / **Hydrophthalmus.** Gr. *ὕδωρ*, water, and *ὀφθαλμός*, the eye.

Hypæmia.
Hyphæma. } Gr. ὕφαιμα, from ὑπό, under, and αἷμα, blood.
Hyphæmia.
Hyperbolic. Gr. ὑπερβολικός, from ὑπερβάλλειν, to throw or reach beyond.
Hypermetropia. Gr. ὑπέρ, beyond, μετρον, a measure, and ὄψις, vision.
Hyperopia. Gr. ὑπέρ, over, and ὄψις, vision. See Hypermetropia.
Hyperopsia. Gr. ὑπέροψία, or ὑπέρψις, from ὑπερόψομαι, overlooking.
Hypertonia. Gr. ὑπέρτονος, from ὑπέρ, over, and τείνω, to stretch.
Hypometropia. Gr. ὑπό, under, μέτρον, measure, and ὄψις, vision.
Hypopyon.
Hypopyum. } Gr. ὑπό, under, and πύον, pus.
Hypotonia. Gr. ὑπό, under, and τόνος, tension.

I.

Idioptcy. Gr. ἴδιος, one's own, and ὤψ, sight. See Achromatopsia.
Illacrimatio. See Epiphora.
Illaqueatio. Lat. from *illaqueare*, to ensnare.
Incapsulation. Lat. *incapsulatio*, from *in*, in, and *capsula*, dimin. of *capsa*, from *capio*, to contain.
Incarceration. Lat. *incarceratio*, from *in*, in, and *carcerare*, to imprison.
Incisuræ. Lat. *incisura*, an incision.
Inclusion. Lat. *inclusio*, from *in*, in, and *cludere*, to shut.
Inocular. Lat. *in*, in, and *oculus*, the eye.
Insufficiency. Lat. *insufficientia*, from *in*, in, and *sufficientia*, a sufficiency.
Intercalar.
Intercalary. } Lat. *intercalaris*, *intercalarius*, from *intercalare*, to insert.
Intercalated.
Inter-pupillary. Lat. *inter*, between, and *pupillaris*, belonging to the pupil.
Intra-ocular. Lat. *intra*, within, and *oculus*, the eye.
Intra-orbital. Lat. *intra*, within, and *orbita*, the orbit.
Iracundus. Lat. *iracundus*, from *ira*, anger.
Iralgia.
Irealgia. } Gr. ἶρις, the iris, and ἄλγος, pain.
Ireancistron.
Ireankistron. } See Iriankistrium.
Irediremia. See Iridiremia.
Ireoncion. See Iridoncus.
Ireoperisphinxis. Gr. ἶρις, the iris, περί, around, and σφίγξις, a constriction.
Iriancistron.
Iriankistrium. } Gr. ἶρις, the iris and ἄγκιστρον, a fish-hook.
Iriankistron.
Iridadenosis. Gr. ἶρις, the iris, and ἀδήν, a gland.
Iridæmia. Gr. ἶρις, the iris, and αἷμα, blood.
Iridalgia. Gr. ἶρις, the iris, and ἄλγος, pain.
Iridallochrosis.
Iridoallochrosis. } Gr. ἶρις, the iris, ἄλλος, different, and χρῶσις, a coloring.
Iridancistron.
Iridankistron. } See Iriankistrium.

Iridaræosis. Gr. ἶρις, the iris, and ἀραίωσις, becoming thin, atrophy.
Iridauxe. Gr. ἶρις, the iris, and αὔξη, growth.
Iridauxesis. Gr. ἶρις, the iris, and αὔξησις, growth.
Iridavulsion. } Gr. ἶρις, the iris, and Lat. *avulsio*, a tearing off.
Iridoavulsion. }
Iridectomedialysis. Gr. ἶρις, the iris, ἐκτομή, a cutting out, and διάλυσις, a pulling apart.
Iridectomy. } Gr. ἶρις, the iris, and ἐκτομή, a cutting out.
Irido-ectomy. }
Iridectropion. } Gr. ἶρις, the iris, and ἐκτρόπιον, a turning out.
Iridectropium. }
Irideleosis. Gr. ἶρις, the iris, and ἕλκωσις, ulceration.
Iridencleisis. }
Iridencleismus. }
Iridenkleisis. } Gr. ἶρις, the iris, and εγκλεῖν, to shut in.
Iridoencleisis. }
Iridotencleisis. }
Iridentropium. Gr. ἶρις, the iris, and ἐντροπή, a turning toward.
Irideremia. Gr. ἶρις, the iris, and ἐρημία, the want of
Iridesis. Gr. ἶρις, the iris, and δέσις, a binding.
Iridocele. Gr. ἶρις, the iris, and κήλη, a tumor.
Iridochoroiditis. Gr. ἶρις, the iris, χοριοειδής, the choroid, and *itis*, denoting inflammation.
Iridocinesis. } Gr. ἶρις, the iris, and κίνησις, movement.
Iridokinesis. }
Iridocoloboma. Gr. ἶρις, the iris, and κολόβωμα, imperfection.
Iridocyclitis. Gr. ἶρις, the iris, κύκλος, a circle, and *itis*, denoting inflammation.
Irido-cyclo-choroiditis. Gr. ἶρις, the iris, κύκλος, a circle, χοριοειδής, the choroid, and *itis*, denoting inflammation.
Iridocyte. Gr. ἶρις, the iris, and κύτος, a cell.
Iridodesis. } Gr. ἶρις, the iris, and δέσις, a binding.
Iriodesis. }
Iridodialysis. Gr. ἶρις, the iris, and διάλυσις, a separating.
Iridodiastasis. Gr. ἶρις, the iris, and διάστασις, a separation.
Irido-donesis. Gr. ἶρις, the iris, and δονεῖν, to shake.
Iridoleptynsis. Gr. ἶρις, the iris, and λέπτυνσις, a making thin.
Iridomalacia. Gr. ἶρις, the iris, and μαλακία, softness.
Iridomedialysis. } Gr. ἶρις, the iris, μέσος, middle, and διάλυσις, a separating.
Iridomesodialysis. }
Iridomelanoma. Gr. ἶρις, the iris, and μελάνωμα, blackness.
Iridomelanosis. Gr. ἶρις, the iris, and μελάνωσις, a becoming black.
Irido-motor. Gr. ἶρις, the iris, and Lat. *movere*, to move.
Iridoncosis. Gr. ἶρις, the iris, and ὄγκωσις, a puffing out.
Iridoncus. Gr. ἶρις, the iris, and ὄγκος, a tumor.
Iridoodea. Gr. ἶρις, the iris, ὠόν, an egg, and εἶδος, resemblance.
Iridoparalysis. Gr. ἶρις, the iris, and παράλυσις, paralysis.
Iridoparelkysis. Gr. ἶρις, the iris, and παρέλκυσις, a delaying.
Iridoparesis. Gr. ἶρις, the iris, and πάρεσις, a letting go.
Iridoperiphacitis. } Gr. ἶρις, the iris, περί, around, φακός, lentil, and *itis*, denoting inflammation.
Iridoperiphakitis. }

Iridoperiphractis. Gr. ἶρις, the iris, περί, around, and φρακτός, fenced in.
Iridoperisphinxis. Gr. ἶρις, the iris, περί, around, and σφίγξις, a binding tight.
Iridophlebocolpos. Gr. ἶρις, the iris, φλέψ, a vein, and κόλπος, the bosom.
Iridoplania. Gr. ἶρις, the iris, and πλάνη, a wandering.
Iridoplasma. Gr. ἶρις, the iris, and πλάσμα, anything moulded.
Iridoplegia. Gr. ἶρις, the iris, and πληγή, a blow.
Iridoptosis. Gr. ἶρις, the iris, and πτῶσις, a falling.
Iridorrhagis. Gr. ἶρις, the iris, and ῥαγάς, a rent.
Iridorrhexis. Gr. ἶρις, the iris, and ῥῆξις, a cleft.
Iridorrhoge. } Gr. ἶρις, the iris, and ῥώξ, a cleft.
Iridorhox. }
Iridorrhytidoma. } Gr. ἶρις, the iris, and ῥυτίς, a fold.
Iridorrhytidosis. }
Iridoschisis. G. ἶρις, the iris, and σχίσις, a cleaving.
Iridoschisma. Gr. ἶρις, the iris, and σχίσμα, a cleft.
Iridosteresis. Gr. ἶρις, the iris, and στέρησις, a taking away.
Iridotome. Gr. ἶρις, the iris, and τομή, a cutting.
Iridotomedialysis. Gr. ἶρις, the iris, τομή, a cutting, and διάλυσις, a separating.
Iridotomencleisis. Gr. ἶρις, the iris, τομή, a cutting, and ἐγκλεῖν, to enclose.
Iridotomia. } Gr. ἶρις, the iris, and τομή, a cutting.
Iridotomy. }
Iridotromos. } Gr. ἶρις, the iris, and τρόμος, a trembling.
Iridotromus. }
Iridovalosis. Gr. ἶρις, the iris, and Lat. *ovum*, an egg.
Iris. Gr. ἶρις, a rainbow.
Iriditis. }
Irisitis. } Gr. ἶρις, the rainbow.
Iritis. }
Iritomy. Gr. ἶρις, the iris, and τομή, a cutting.

K.

Kaleidoscope. Gr. καλός, beautiful, εἶδος, like, and σκοπεῖν, to view.
Keratalgia. Gr. κέρας, a horn, and ἄλγος, pain.
Keratectasia. Gr. κέρας, a horn, and ἔκτασις, a displacement, stretching.
Keratectomy. } Gr. κέρας, a horn, and ἐκτομή, a cutting out.
Kerectomy. }
Keratitis. }
Keratodeitis. } Gr. κέρας, a horn, and *itis*, denoting inflammation.
Keratodermatitis. }
Keratocele. }
Keratodeocele. } Gr. κέρας, a horn, and κήλη, a tumor.
Keratodermatocele. }
Keratochromatosis. Gr. κέρας, a horn, and χρῶμα, color.
Keratoconjunctivitis. Gr. κέρας, a horn, Lat. *conjunctiva*, the conjunctiva, and *itis*, denoting inflammation.
Keratoconus. Gr. κέρας, a horn, κῶνος, a cone.
Keratodermatomalacia. Gr. κέρας, a horn, δέρμα, the skin, and μαλακία, softening.
Keratoglobus. Gr. κέρας, a horn, and Lat. *globus*, a globe.
Kerato-iritis. Gr. κέρας, a horn, ἶρις, the iris, and *itis*, denoting inflammation.

Keratoleucoma. Gr. *κέρας*, a horn, and *λεύκωμα*, anything whitened.
Keratomalacia. Gr. *κέρας*, a horn, and *μαλακία*, a softening.
Keratomeninx. Gr. *κέρας*, a horn, and *μῆνιγξ*, a membrane.
Keratometer. Gr. *κέρας*, a horn, and *μέτρον*, a measure.
Keratomycosis. Gr. *κέρας*, a horn, and *μύκης*, a fungus.
Keratonyxis.
Keratodeonyxis. } Gr. *κέρας*, a horn, and *νύξις*, a pricking.
Keratoplasty. Gr. *κέρας*, a horn, and *πλάσσειν* (from *πλάσσω*) to mould.
Keratorrhexis. Gr. *κέρας*, a horn, and *ῥῆξις*, a rent.
Keratoscleritis. Gr. *κέρας*, a horn, *σκληρός*, hard, and *itis*, denoting inflammation.
Keratoscope.
Keratoscopy. } Gr. *κέρας*, a horn, and *σκοπεῖν*, to view.
Keratotome.
Keratotomy.
Keratome.
Keratomus. } Gr. *κέρας*, a horn, and *τέμνειν*, to cut.
Kerectasia. Gr. *κέρας*, a horn, and *ἔκτασις*, a stretching.
Kopiopia. See Copopsia.
Korascopy. Gr. *κόρη*, the pupil, and *σκοπεῖν*, to view.
Kyklitis. See Cyclitis.

L.

Lachrima.
Lacryma. } Lat. *lacrima*, a tear.
Lacrimation. Lat. *lacrimatio*, from *lacrimare*, to shed tears.
Lacrymal. Lat. *lacrimalis*, from *lacrima*, a tear.
Lacrymotome. Lat. *lacrima*, a tear, and *τομή*, an incision.
Lacus lacrimalis. Lat. *lacus*, a lake. Gr. *λάκος*, a lake, and Lat. *lacrimalis*, lacrymal.
Lagophthalmia.
Lagophthalmos.
Lagophthalmus. } Gr. *λαγώς*, a hare, and *ὀφθαλμός*, the eye.
Lamella. Lat. *lamella*, dimin. of *lamina*. See Lamina.
Lamina. Lat. *lamina*, a thin plate.
Lens. Lat. *lens*, lentil.
Lenticonus. Lat. *lens*, a lentil, and *conus*, a cone.
Leptothrix lachrymalis. Gr. *λεπτός*, slender, *θρίξ*, a hair, and Lat. *lacrimalis*, from *lacrima*, a tear.
Leucoma. Gr. *λεύκωμα*, anything whitened.
Ligamentum annulare. Lat. *ligamentum*, a ligament, and *annularis*, from *annulus*, a ring.
Ligamentum pectinatum. Lat. *ligamentum*, a ligament, and *pectinatum*, from *pecten*, a comb.
Limbus. Lat. *limbus*, a margin.
Lippitudo.
Lippus. } Lat. *lippitudo*, from *lippus*, blear-eyed.
Liquor Morgagni. Lat. *liquor*, from *liquere*, to be liquid, and *Morgagni*.
Lucifugus. Lat. *lux*, light, and *fugere*, to shun.
Lusciosity. Lat. *lusciositas*, from *lusciosus*, purblind.
Luxation. Lat. *luxatio*, a dislocation.

M.

Macrophthalmus. Gr. μακρός, large, and ὀφθαλμός, the eye.

Macropia.
Macropsia. } Gr. μακρός, large, and ὄψις, vision.

Macroscopic. Gr. μακρός, large, and σκοπεῖν, to view.

Macula lutea. Lat. *macula*, a spot, and *luteus*, yellow.

Madarosis. Gr. μαδάρωσις, a making bald.

Megalocornea. Gr. μέγας, large, and Lat. *cornu*, a horn.

Megalophthalmus. Gr. μέγας, large, and ὀφθαλμός, the eye.

Megalopia.
Megalopsia. } Gr. μέγας, large, and ὄψις, vision.

Meniscus. Gr. μηνίσκος, dimin. of μήνη, a crescent.

Metamorphopsia. Gr. μετμόρφωσις, a transformation, and ὄψις, vision.

Metre-angle. Gr. μέτρον, a measure, and Lat. *angulus*, angle, from Gr. ἀγκύλος, bent.

Metre-lens. Gr. μέτρον, a measure, and Lat. *lens*, a lentil.

Microphthalmia.
Microphthalmus. } Gr. μικρός, small, and ὀφθαλμός, the eye.

Micropia.
Micropsia. } Gr. μικρός, small, and ὄψις, vision.

Milium. Lat. *milium*, a millet-seed.

Molluscum contagiosum. Lat. *molluscum*, a knotty growth, and *contagiosus*, contagious.

Monochromatic.
Monochromous.
Monochroous. } Gr. μόνος, alone, and χρῶμα, color.

Monocular.
Monoculous.
Monoculus. } Gr. μόνος, single, and Lat. *oculus*, an eye.

Monodiplopia. Gr. μόνος, single, διπλόος, double, and ὄψις, vision.

Monophthalmia.
Monophthalmus. } Gr. μόνος, single, and ὀφθαλμός, the eye.

Moon-blindness. See Hemeralopia.

Muscæ volitantes. Lat. *musca*, a fly, and *volitare*, to fly about.

Mydriasis.
Mydriatic. } Gr. μυδρίασις, from μύδος, moisture; because increase of fluids causes pupil to dilate (?).

Myiocephalon. Gr. μυῖα, a fly, and κεφαλή, the head.

Myiodeopsia.
Myiodesopsia.
Myodesopia.
Myodesopsia.
Myodopsia.
Myopsia. } Gr. μυιώδης, like flies, and ὤψ, vision.

Myopia.
Myopiosis.
Myopy. } Gr. μύωψ, from μύειν, to close, and ὤψ, the eye.

Myopodiorthoter.
Myopodiorthoticon. } Gr. μύωψ, short-sighted, and ὀρθότης, straightness.

Myoporthon.
Myoporthosis.
Myopodiorthosis. } Gr. *μύωψ*, short-sighted, and *ὀρθός*, straight.

Myosis.
Myotic. } Gr. *μύειν*, to close.

N.

Nebula. Lat. *nebula*, a cloud.

Neonatorum. Gr. *νέος*, new, and Lat. *natus*, born.

Neuritis optica. Gr. *νεῦρον*, a nerve, *itis*, denoting inflammation, and *ὀπτικός*, optic.

Neuroparalytic. Gr. *νεῦρον*, a nerve, and *παραλυτικός*, loosened.

Neuro-retinitis. Gr. *νεῦρον*, nerve, Lat. *retina*, the retina, and *itis*, denoting inflammation.

Nictation.
Nictitation. } Lat. *nictatio*, from *nictare*, to wink.

Night-blindness. See Nyctalopia.

Niphablepsia. Gr. *νιφάς*, snow, and *ἀβλεψία*, blindness.

Nyctalopia. Gr. *νύξ*, night, and *ὤψ*, vision.

Nyctamblyopia. Gr. *νύξ*, night, and *ἀμβλυωπία*, dim-sightedness.

Nyctotyphlosis. Gr. *νύξ*, night, and *τύφλωσις*, a making blind.

Nystagmus. Gr. *νυσταγμός*, a nodding.

O.

Objective. Lat. *objectus*, from *objicere*, to throw before.

Oblique. Lat. *obliquus*, from *obliquare*, to bend.

Occlusion. Lat. *occlusio*, from *occludere*, the close.

Ocular. Lat. *ocularis*, from *oculus*, the eye.

Ocular-Untersuchung. Lat. *ocularis*, ocular, and Ger. *Untersuchung*, examination.

Oculist. Lat. *oculista*, from *oculus*, the eye.

Oculo-frontal. Lat. *oculus*, the eye, and *frons*, the forehead.

Oculo-motor.
Oculomotorius. } Lat. *oculus*, the eye, and *movere*, to move.

Oculomuscularis. Lat. *oculus*, the eye, and *musculus*, a muscle.

Oculo-nasal. Lat. *oculus*, the eye, and *nasus*, the nose.

Oculopupillary. Lat. *oculus*, the eye, and *pupilla*, the pupil.

Oculozygomatic. Lat. *oculus*, the eye, and Gr. *ζύγωμα*, the zygoma.

Oculus. Lat. *oculus*, the eye.

Onyx. Gr. *ὄνυξ*, finger-nail.

Opacity. Lat. *opacitas*, from *opacus*, darkened.

Ophthalmagra. Gr. *ὀφθαλμός*, the eye, and *ἄγρα*, a catching.

Ophthalmalgia. Gr. *ὀφθαλμός*, the eye, and *ἄλγος*, pain.

Ophthalmemicrania. Gr. *ὀφθαλμός*, the eye, *ἡμι*, *half*, and *κρανίον*, the skull.

Ophthalmempasma. Gr. *ὀφθαλμός*, the eye, and *ἐμπάσσειν*, to sprinkle.

Ophthalmencephalon. Gr. *ὀφθαλμός*, the eye, and *ἐγκέφαλος*, within the head.

Ophthalmentozoon. Gr. *ὀφθαλμός*, the eye, *ἐντός*, within, and *ζῶον*, an animal.

Ophthalmia. Gr. *ὀφθαλμία*, from *ὀφθαλμός*, the eye.

Ophthalmiater. Gr. *ὀφθαλμός*, the eye, and *ἰατρός*, a surgeon.

Ophthalmiatrics. Gr. *ὀφθαλμός* the eye, and *ἰατρική*, surgery, or *ἰατρεία*, a means of healing.

Ophthalmic. Gr. ὀφθαλμικός, from ὀφθαλμός, the eye.
Ophthalmidium. Dimin. of ophthalmos, from Gr. ὀφθαλμός, the eye. See Microphthalmus.
Ophthalmitis. Gr. ὀφθαλμός, the eye, and *itis*, denoting inflammation.
Ophthalmium. Dimin. of ophthalmos, from Gr. ὀφθαλμός, the eye.
Ophthalmobiotic. Gr. ὀφθαλμός, the eye, and βιοῦν, to live.
Opthalmoblennorrhœa. Gr. ὀφθαλμός, the eye, βλέννα, mucus, and ῥεῖν, to flow.
Ophthalmobrachytes. Gr. ὀφθαλμός, the eye, and βραχύτης, shortness.
Ophthalmocarcinoma. Gr. ὀφθαλμός, the eye, and καρκίνωμα, a cancer.
Ophthalmocele. Gr. ὀφθαλμός, the eye, and κήλη, a tumor.
Ophthalmocentesis. Gr. ὀφθαλμός, the eye, and κέντησις, puncture.
Ophthalmocholosis. Gr. ὀφθαλμός, the eye, and χόλος, bile.
Ophthalmochroites. Gr. ὀφθαλμός, the eye, and χροίζειν, to color.
Ophthalmoconjunctivitis. See Ophthalmia and Conjunctivitis.
Ophthalmocopia. Gr. ὀφθαλμός, the eye, and κόπος, fatigue.
Ophthalmodesmitis. Gr. ὀφθαλμος, the eye; δεσμός, a bond, and *itis*, denoting inflammation.
Ophthalmodesmon.
Ophthalmodesmum. Gr. ὀφθαλμός, the eye, and δεσμός, a bond.
Ophthalmodesmoxerosis. Gr. ὀφθαλμός, the eye, δεσμός, a bond, and ξηρός, dry.
Ophthalmodynamometer. Gr. ὀφθαλμος, the eye, δύναμις, force, and μέτρον, measure.
Ophthalmodynia. Gr. ὀφθαλμός, the eye, and ὀδύνη, pain.
Ophthalmœdema. Gr. ὀφθαλμός, the eye, and οἴδημα, œdema.
Ophthalmography. Gr. ὀφθαλμός, the eye, and γράφειν, to write.
Ophthalmohydrorrhœa. See Ophthalmydrorrhœa.
Ophthalmolith. Gr. ὀφθαλμός, the eye, and λίθος, a stone.
Ophthalmology. Gr. ὀφθαλμός, the eye, and λόγος, discourse.
Ophthalmolyma. Gr. ὀφθαλμός, the eye, and λύμη, destruction.
Ophthalmomacrosis. Gr. ὀφθαλμός, the eye, and μάκρωσις, an enlarging.
Ophthalmomalacia. Gr. ὀφθαλμός, the eye, and μαλακία, softness.
Ophthalmomelanoma. Gr. ὀφθαλμός, the eye, and μέλας, black.
Ophthalmomelanosis. Gr. ὀφθαλμός, the eye, and μελάνωσις, from μέλανσις, a becoming black.
Ophthalmometer.
Ophthalmometry. Gr. ὀφθαλμός, the eye, and μέτρον, a measure.
Ophthalmomyitis.
Ophthalmomyositis. Gr. ὀφθαλμος, the eye, μῦς, muscle, and *itis*, denoting inflammation.
Ophthalmomyotony. Gr. ὀφθαλμός, the eye, μῦς, a muscle, and τομή, a cutting.
Ophthalmoncus. Gr. ὀφθαλμός, the eye, and ὄγκος, a tumor.
Ophthalmoneuromeninx.
Ophthalmoneurymen. Gr. ὀφθαλμός, the eye, νεῦρον, a nerve, and μῆνιγξ, a membrane.
Ophthalmonosology. Gr. ὀφθαλμός, the eye, νόσος, disease, and λόγος, discourse.
Ophthalmoparacentesis. Gr. ὀφθαλμός, the eye, and παρακέντησις, perforation.
Ophthalmoparalysis. Gr. ὀφθαλμος, the eye, and παράλυσις, a loosening.
Ophthalmoperiphritis. Gr. ὀφθαλμός, the eye, περιφέρεια, a periphery, and *itis*, denoting inflammation.
Ophthalmophantoma. Gr. ὀφθαλμός, the eye, and φάντασμα, a phantom.
Ophthalmophlebitis. Gr. ὀφθαλμος, the eye, φλέψ, a vein, and *itis*, denoting inflammation.

Ophthalmophlebotomy. Gr. ὀφθαλμός, the eye, φλέψ, a vein, and τομή, a cutting.
Ophthalmophtharsis. Gr. ὀφθαλμός, the eye, and φθάρσις, corruption.
Ophthalmophthisis. Gr. ὀφθαλμός, the eye, and φθίσις, decay.
Ophthalmophyma. Gr. ὀφθαλμός, the eye, and φῦμα, a growth.
Ophthalmoplegia. Gr. ὀφθαλμός, the eye, and πληγή, a stroke.
Ophthalmoponia. Gr. ὀφθαλμός, the eye, and πόνος, labor.
Ophthalmoprosopsis. Gr. ὀφθαλμός, the eye, and πρόσοψις, appearance.
Ophthalmoprostatometer. Gr. ὀφθαλμός, the eye, προϊστάναι, to stand before, and μέτρον, a measure.
Ophthalmoptoma. Gr. ὀφθαλμός, the eye, and πτῶμα, a fall.
Ophthalmoptosis. Gr. ὀφθαλμός, the eye, and πτῶσις, a falling.
Ophthalmopyorrhœa. Gr. ὀφθαλμός, the eye, πύον, pus, and ῥεῖν, to flow.
Ophthalmopyra. Gr. ὀφθαλμός, the eye, and πῦρ, fever heat.
Ophthalmorrhagia. Gr. ὀφθαλμός, the eye, and ῥηγνύναι, to burst.
Ophthalmorrhexis. Gr. ὀφθαλμός, the eye, and ῥῆξις, a bursting.
Ophthalmorrhœa. Gr. ὀφθαλμός, the eye, and ῥοία, a flowing.
Ophthalmos. } Gr. ὀφθαλμός, the eye.
Ophthalmus. }
Ophthalmoscope. Gr. ὀφθαλμός, the eye, and σκοπεῖν, to examine.
Ophthalmoscopometer. Gr. ὀφθαλμός, the eye, σκοπεῖν, to view, and μέτρον, a measure.
Ophthalmoscopy. Gr. ὀφθαλμός, the eye, and σκοπεῖν, to examine.
Ophthalmospasmus. Gr. ὀφθαλμός, the eye, and σπασμός, a spasm.
Ophthalmospintherism. Gr. ὀφθαλμός, the eye, and σπινθήρ, a spark.
Ophthalmostat. Gr. ὀφθαλμός, the eye, and στατός, from ἱστάναι, to place.
Ophthalmostatometer. } Gr. ὀφθαλμός, the eye, στατός, placed, and μέτρον, a
Ophthalmostatometry. } measure.
Ophthalmosteresis. Gr. ὀφθαλμός, the eye, and στέρησις, deprivation.
Ophthalmosynchysis. Gr. ὀφθαλμός, the eye, and σύγχυσις, a mixing together.
Ophthalmotherapeutics. Gr. ὀφθαλμός, the eye, and θεραπεία, a waiting on.
Ophthalmotomy. Gr. ὀφθαλμός, the eye, and τομή, a cutting.
Ophthalmotonometer. Gr. ὀφθαλμός, the eye, τόνος, tension, and μέτρον, measure.
Ophthalmotrope. Gr. ὀφθαλμός, the eye, and τροπή, a turning.
Ophthalmotropometer. Gr. ὀφθαλμός, the eye, τροπή, a turning, and μέτρον, a measure.
Ophthalmotropometry. Gr. ὀφθαλμός, the eye, τροπή, a turning, and μέτρειν, to measure.
Ophthalmotyphus. Gr. ὀφθαλμός, the eye, and τῦφος, smoke.
Ophthalmoxerosis. Gr. ὀφθαλμός, the eye, and ξηρός, dry.
Ophthalmoxysis. Gr. ὀφθαλμός, the eye, and ξύσις, a scratching.
Ophthalmoxystrum. Gr. ὀφθαλμός, the eye, and ξύστρα, a scraper.
Ophthalmoxygomatogramma. Gr. ὀφθαλμός, the eye, ζύγωμα, a crossbar, and γράμμα, a line.
Ophthalmozoon. Gr. ὀφθαλμός, the eye, and ζῶον, an animal.
Ophthalmula. Gr. ὀφθαλμός, the eye, and ὕλη, matter.
Ophthalmuria. Gr. ὀφθαλμός, the eye, and οὖρον, urine.
Ophthalmyalos. } Gr. ὀφθαλμός, the eye, and ὕαλος, glass.
Ophthalmyalus. }
Ophthalmydrorrhœa. Gr. ὀφθαλμός, the eye, ὕδωρ, water, and ῥεῖν, to flow.
Ophthalmymenitis. Gr. ὀφθαλμός, the eye, and ὑμήν, a membrane.

Opsiometer. Gr. *ὄψις*, vision, and *μέτρον*, a measure.
Opsionusi. Gr. *ὄψις*, vision, and *νοῦσος*, disease.
Opsis. Gr. *ὄψις*, vision.
Optactin. Gr. *ὀπτός*, visible, and *ἀκτίς*, a ray.
Optician. Gr. *ὀπτικός*, from *ὁρᾶν*, to see.
Optico-ciliary. Lat. *opticus*, optic, and *ciliaris*, ciliary.
Opticocinerea. Gr. *ὀπτικός*, optic, and Lat. *cinereus*, similar to ashes.
Optics. Gr. *ὀπτικά*, from *ὀπτικός*, from *ὁρᾶν*, to see.
Optilos. Gr. *ὀπτίλος*, the eye.
Optigram. Gr. *ὀπτικός*, visible, and *γράμμα*, a letter.
Optograph. Gr. *ὀπτικός*, visible, and *γράφειν*, to write.
Optomeninx. Gr. *ὀπτός*, visible, and *μῆνιγξ*, a membrane.
Optometer. }
Optometry. } Gr. *ὀπτός*, visible, and *μέτρον*, a measure.
Optoscope. Gr. *ὀπτός*, visible, and *σκοπεῖν*, to examine.
Optotype. Lat. *opto*, from Gr. *ὄψομαι*, to look out, and *typus*, type.
Ora serrata. Lat. *ora*, a boundary, and *serratus*, serrated.
Orbicular. Lat. *orbicularis*, from *orbis*, a circle.
Orbit. Lat. *orbita*, from *orbis*, a circle.
Orbitocele. Lat. *orbita*, the orbit, and Gr. *κηλή*, a tumor.
Orientation. Lat. *orientatio*, from *oriens*, the east.
Oxydercis. Gr. *ὀξυδερκής*, sharp-sighted.
Oxydercia. Gr. *ὀξυδερκία*, sharp-sightedness.
Oxyopia. Gr. *ὀξύς*, sharp, and *ὄψις*, vision.

P.

Pachyblepharon. }
Pachyblepharosis. } Gr. *παχύς*, thick, and *βλέφαρον*, the eyelid.
Pachyblepharum. }
Palpebral. Lat. *palpebralis*, from *palpebra*, the eyelid.
Palpebratio. See Nictitation.
Palpebritis. See Blepharitis.
Pannus. Lat. *pannus*, a cloth.
Panophthalmitis. Gr. *πᾶς*, all, *ὀφθαλμός*, the eye, and *itis*, denoting inflammation.
Papilla. Lat. *papilla*, a nipple.
Papillitis. Lat. *papilla*, a nipple, and *itis*, denoting inflammation.
Papilloretinitis. Lat. *papilla*, a nipple, *retina*, the retina, and *itis*, denoting inflammation.
Paracentesis. Gr. *παρακέντησις*, perforation.
Parachroma. Gr. *παρά*, beside, and *χρῶμα*, color.
Parachromatoblepsia. Gr. *παρά*, beside, *χρῶμα*, color, and *βλέψις*, sight.
Paralampsis. Gr. *παράλαμψις*, from *παρά*, beside, and *λάμπω*, to shine.
Parallaxis. Gr. *παράλλαξις*, alternation.
Parophthalmia. Gr. *παρά*, beside, and *ὀφθαλμός*, the eye.
Parophthalmoncus. Gr. *παρά*, beside, *ὀφθαλμός*, the eye, and *ὄγκος*, a tumor.
Paropia. }
Paropsis. } Gr. *παρωπία*, from *παρά*, beside, and *ὤψ*, the eye (corner of the eye next to the temple).
Paropion. }
Paropium. } Gr. *παρώπιον*, a blinker, blinder.

Paropsis. Gr. *παρά*, beside, and *ὄψις*, vision.
Parorasis. Gr. *παρόρασις*, from *παρά*, beside, and *ὁρᾶν*, to see.
Patellaris. Lat. *patella*, a dish.
Perichoroid. Gr. *περί*, around, *χόριον*, the choroid, and *εἶδος*, resemblance.
Pericorneal. Gr. *περί*, around, and Lat. *cornealis*, corneal.
Peridectomy. Gr. *περί*, around, and *ἐκτομή*, a cutting out.
Perimeter.
Perimetry. } Gr. *περί*, around, and *μέτρον*, a measure.
Periophthalmitis. Gr. *περί*, around, *ὀφθαλμός*, the eye, and *itis*, denoting inflammation.
Perioptometry. Gr. *περί*, around, *ὀπτός*, visible, and *μέτρον*, a measure.
Periorbita. Gr. *περί*, around, and Lat. *orbita*, the orbit.
Periscopic. Gr. *περί*, around, and *σκοπεῖν*, to see.
Peritomy. Gr. *περί*, around, and *τέμνειν*, to cut.
Phacc.
Phacea.
Phacia.
Phacus. } Gr. *φακός*, a lentil.
Phacentocele. Gr. *φακός*, a lentil, *ἐντός*, *within*, and *κήλη*, a tumor.
Phacitis.
Phakitis. } Gr. *φακός*, lentil, and *itis*, denoting inflammation.
Phacocatapiesis. Gr. *φακός*, a lentil, and *καταπίεσις*, a pressing down.
Phacocatathesis. Gr. *φακός*, a lentil, and *κατάθεσις*, a laying down.
Phacocysta. Gr. *φακός*, a lentil, and *κύστις*, a bladder.
Phacocystectome. Gr. *φακός*, a lentil, *κύστις*, a bladder, and *ἐκτομή*, a cutting out.
Phacocystitis. Gr. *φακός*, a lentil, *κύστις*, a bladder, and *itis*, denoting inflammation.
Phacoglaucoma. Gr. *φακός*, a lentil, and *γλαύκωμα*, opacity of the crystalline lens.
Phacohydropsis.
Phacydrops.
Phacydropsia. } Gr. *φακός*, a lentil, and *ὕδρωψ*, watery humor.
Phacohymenitis.
Phacymenitis. } Gr. *φακός*, a lentil, *ὑμήν*, a membrane, and *itis*, denoting inflammation.
Phacoidoscope. Gr. *φακός*, a lentil, *εἶδος*, resemblance, and *σκοπεῖν*, to examine.
Phacomalacia. Gr. *φακός*, a lentil, and *μαλακία*, softness.
Phacometachoresis. Gr. *φακός*, a lentil, and *μεταχώρησις*, a going from one place to another.
Phacometœcesis. Gr. *φακός*, a lentil, and *μετοίκησις*, change of abode.
Phacometer. Gr. *φακός*, a lentil, and *μέτρον*, a measure.
Phaconin. Fr. phaconine (the globulin of the crystalline lens).
Phacopalingenesis. Gr. *φακός*, a lentil, *πάλιν*, again, and *γένεσις*, creation.
Phacoplanesis. Gr. *φακός*, a lentil, and *πλάνησις*, a making to wander.
Phacoplasma. Gr. *φακός*, a lentil, and *πλάσσειν*, to form.
Phacopyosis. Gr. *φακός*, a lentil, and *πύωσις*, suppuration.
Phacoscleroma. Gr. *φακός*, a lentil and *σκλήρωμα*, induration.
Phacosclerosis. Gr. *φακός*, a lentil, and *σκληρῶσις*, induration.
Phacoscope Gr. *φακός*, a lentil, and *σκοπεῖν*, to examine.
Phacoscotasmus. Gr. *φακός*, a lentil, and *σκοτασμός*, a making dark.
Phacoscotoma. Gr. *φακός*, a lentil, and *σκότος*, darkness.
Phacosis. Gr. *φάκωσις*, from *φακός*, a lentil.

Phantasmascopia.
Phantasmatoscopia.
Phantasmoscope.
Phantasmoscopy. } Gr. φάντασμα, a phantom, and σκοπεῖν, to examine.

Phlyctenule. Gr. φλύκταινα, a blister.

Phosphene. Gr. φῶς, light, and φαίνειν, to appear.

Photalgia. Gr. φῶς, light, and ἄλγος, pain.

Photics. Gr. φῶς, light. See Optics.

Photocampsis. Gr. φῶς, light, and κάμψις, a bending.

Phodysphoria. Gr. φῶς, light, and δυσφορία, excessive pain.

Photology. Gr. φῶς, light, and λόγος, discourse. See Optics.

Photometer. Gr. φῶς, light, and μέτρον, a measure.

Photonosus. Gr. φῶς, light, and νόσος, disease.

Photoparæsthesia. Gr. φῶς, light, παρά, beside, and αἴσθησις, sensation.

Photophobia. Gr. φῶς, light, and φόβος, fear.

Photophobophthalmia. Gr. φῶς, light, φόβος, fear, and ὀφθαλμός, the eye.

Photopsia. Gr. φῶς, light, and ὄψις, vision.

Photoptometry. Gr. φῶς, light, ὀπτός, visible, and μέτρον, a measure.

Photorrhexis. Gr. φῶς, light, and ῥῆξις, a breaking.

Phthisis bulbi. Gr. φθίσις, a wasting, and Lat. *bulbus*, a bulb, or Gr. βολβός, bulb.

Pinguicula. Lat. *pinguis*, fat.

"Pink-eye." Eng. pink-eye.

Plane. Lat. *planus*, level, flat.

Plano-concave. Lat. *planus*, flat, and *concavus*, concave.

Plano-convex. Lat. *planus*, flat, and *convexus*, convex.

Platycoria.
Platycoriasis. } Gr. πλατύς, broad, and κόρη, the pupil.

Platyophthalmus. Gr. πλατυοφθαλμός, having wide eyes.

Pleochroism. Gr. πλείων, more, and χροιά, color.

Plica semilunaris. Lat. *plicare*, to fold, *semi*, half, and *lunaris*, lunar.

Pole. Gr. πόλος, a pole, an axis.

Polycoria. Gr. πολύς, many, and κόρη, the pupil.

Polydacrya. Gr. πολύς, many, and δάκρυον, a tear.

Polyophthalmia. Gr. πολύς, many, and ὀφθαλμός, the eye.

Polyopia.
Polyopsia. } Gr. πολύς, many, and ὄψις, vision.

Porus opticus. Gr. πόρος, a passageway, and ὀπτικός, optic.

Potatorum. Lat. *potator*, a drinker.

Presbyopia. Gr. πρέσβυς, an old man, and ὄψις, vision.

Prism. Gr. πρίσμα, from πρίζειν, to saw.

Prisoptometer. Gr. πρίσμα, a prism, ὀπτός, visible, and μέτρον, a measure.

Projection. Lat. *projicere*, to throw before.

Prophthalmus. Gr. προς, before, and ὀφθαλμός, the eye.

Proptosis oculi. Gr. πρόπτωσις, prolapse, and Lat. *oculus*, the eye.

Prosthesis oculi. Gr. προσθεσις, an adding, and Lat. *oculus*, the eye.

Pseudoblepsia. Gr. ψευδής false, and βλέψις, sight.

Pseudocataracta. Gr. ψευδής, false, and καταῤῥάκτης, cataract.

Pseudochromia. Gr. ψευδής, false, and χρῶμα, color.

Pseudocilia. Gr. ψευδής, false, and *cilium*, an eyelash.

Pseudocoloboma. Gr. ψευδής, false, and, κολόβωμα, a mutilation.

Pseudopia.
Pseudopsia. Gr. *ψευδής*, false, and *ὄψις*, vision.
Pseudorasis. Gr. *ψευδής* false, and *ὁρᾶν*, to see.
Pseudoscope. Gr. *ψευδής*, false, and *σκοπεῖν*, to examine.
Pterygium. Gr. *πτερύγιον*, dimin. from *πτέρυξ*, a wing.
Ptosis. Gr. *πτῶσις*, a falling.
Punctum. Lat. *punctum*, a point.
Pupil. Lat. *pupilla*, dimin. from *pupa*, a girl.
Pupillometer. Lat. *pupilla*, the pupil, and Gr. *μέτρον*, a measure.
Pupilloscopy. Lat. *pupilla*, the pupil, and *σκοπεῖν*, to examine.

R.

Ray. Lat. *radius*, a ray, a beam.
Reclination. Lat. *reclinatio*, from *reclinare*, to lean back.
Rectus. Lat. *rectus*, from *regere*, to lead straight.
Red-blindness. See Anerythropsia.
Reflection. Lat. *reflexio*, from *reflectere*, to bend back.
Refraction. Lat. *refrangere*, to break up.
Retina. Lat. *retina*, from *rete*, a net.
Retinitis. Lat. *rete*, a net, and *itis*, denoting inflammation.
Retinoscopy. Lat. *rete*, a net, and Gr. *σκοπεῖν*, to examine.
Retinula. Lat. *retinula*, dimin. from *retina*, the retina.
Retractor. Lat. *retrahere*, to draw back.
Retrobulbar. Lat. *retro*, behind, and *bulbus*, a bulb.
Rhodopsin. Gr. *ῥόδον*, a rose, and *ὤψ*, the eye.
Rhytidosis. Gr. *ῥυτίδωσις*, a wrinkling.
Rotation. Lat. *rotatio*, from *rotare*, to revolve

S.

Scintillans. Lat. *scintilla*, a spark.
Scirrophthalmia. Gr. *σκίῤῥος*, hard, and *ὀφθαλμία*, ophthalmia.
Sclerectasia. Gr. *σκληρός*, hard, and *ἔκτασις*, a stretching out.
Scleritis. Gr. *σκληρός*, hard, and *itis*, denoting inflammation.
Sclerocataracta. Gr. *σκληρος*, hard, and *καταῤῥάκτης*, a cataract.
Sclerochoroiditis.
Scleroticochoroiditis. Gr. *σκληρος*, hard, *χοριοειδής*, like the choroid, and *itis*, denoting inflammation.
Scleronyxis.
Scleroticonyxis.
Sclerotonyxis. Gr. *σκληρότης*, hardness, and *νύξις*, a pricking.
Scleropthalmia. Gr. *σκληρός*, hard, and *ὀφθαλμία*, opthalmia.
Scleropthalmus. Gr. *σκληρός*, hard, and *ὀφθαλμός*, the eye.
Sclerotic. Gr. *σκληρός*, hard.
Scleroticotomy. Gr. *σκληρότης*, hardness, and *τομή*, an incision.
Sclerotitis.
Scleroticitis. Gr. *σκληρότης*, hardness, and *itis*, denoting inflammation.
Sclerotome. Gr. *σκληρός*, hard, and *τομή*, an incision.
Sclerotomy. Gr. *σκληρός*, hard, and *τέμνειν*, to cut.
Sclerymenitis. Gr. *σκληρός*, hard, *ὑμήν*, a membrane, and *itis*, denoting inflammation. See Sclerotitis.

Scotasmus. Gr. *σκοτασμός*, darkness.
Scotodia. Gr. *σκοτωδία*, becoming dark.
Scotoma. / Scotasma. } Gr. *σκοτός*, darkness.
Scotometer. Gr. *σκοτός*, darkness, and *μέτρον*, a measure.
Scotopsia. Gr. *σκοτός*, darkness, and *ὄψις*, vision.
Scotos. Gr. *σκοτός*, darkness.
Scotosis. Gr. *σκοτωσίς*, darkness.
Seclusio pupillæ. Lat. *seclusio*, seclusion, and *pupilla*, the pupil.
Sight. A.-S. *siht*, *gesiht*, Gr. *ὤψ*, Lat. *visus*.
Skiascopy. Gr. *σκία*, a shadow, and *σκοπεῖν*, to examine.
Snow-blindness. See Niphablepsia.
Spectacles. Lat. *spectaculum*, from *spectare*, to behold.
Spectro-colorimeter. Lat. *spectrum*, a spectre, *color*, color, and Gr. *μέτρον*, a measure.
Spectrology. Lat. *spectrum*, an image, and Gr. *λόγος*, a discourse.
Spectrometer. Lat. *spectrum*, an image, and Gr. *μέτρον*, a measure.
Spectrophotometer. Lat. *spectrum*, a spectre, Gr. *φῶς*, light, and *μέτρον*, a measure.
Spectroscope. Lat. *spectrum*, a spectre, and Gr. *σκοπεῖν*, to examine.
Speculum. Lat. *speculum*, from *specere*, to look at.
Spherical. Gr. *σφαιρικός*, from *σφαῖρα*, a sphere.
Spherico-cylindric. Gr. *σφαιρικός*, spherical, and *κυλινδρικός*, cylindric.
Spherochlorine. Gr. *σφαῖρα*, a sphere, and *χλωρός*, green.
Spherometer. Gr. *σφαῖρα*, a sphere, and *μέτρον*, a measure.
Spherorrhodine. Gr. *σφαῖρα*, a sphere, and *ῥόδον*, a rose.
Spheroxanthine. Gr. *σφαῖρα*, a sphere, and *ξανθός*, yellow.
Sphincter. Gr. *σφιγκτήρ*, that which binds.
Sphincterolysis. Gr. *σφιγκτήρ*, a binder, and *λύσις*, a loosening.
Spintherismus. Gr. *σπινθηρίξειν*, to make sparks.
Spintheroma. Gr. *σπινθήρ*, a spark.
Spintheropia. Gr. *σπινθήρ*, a spark, and *ὄψις*, vision.
Squint. See Strabismus.
Staar. Ger. *staar*, a starling, cataract.
Staphyloma. Gr. *σταφύλωμα*, from *σταφυλή*, a bunch of grapes.
Static. Gr. *στατικός*, causing to stand still.
Statometer. Gr. *στατός*, place, and *μέτρον*, a measure.
Stauungspapille. Ger. *stauen*, to dam, and Lat. *pupilla*, the pupil.
Stenocoriasis. Gr. *στενός*, narrow, and *κόρη*, the pupil.
Stenopæic. Gr. *στενός*, narrow, and *ὀπαῖος*, from *ὀπή*, a hole.
Stereomonoscope. Gr. *στερεός*, solid, *μόνος*, alone, and *σκοπεῖν*, to examine.
Stereophantoscope. Gr. *στερεός*, solid, *φαντός*, visible, and *σκοπεῖν*, to examine.
Stereophoroscope. Gr. *στερεός*, solid, *φορός*, carrying, and *σκοπεῖν*, to examine.
Stereoscope, Stereoscopic. Gr. *στερεός*, solid, and *σκοπεῖν*, to examine.
Stillicidium. Lat. *stillicidium*, a dripping.
Strabismometer. / Strabometer. } Gr. *στραβισμός*, a squinting, and *μέτρον*, a measure.
Strabismus. Gr. *στραβισμός*, squinting.
Strabotomy. Gr. *στραβός*, slanting, and *τομή*, an incision.
Streptothrix. Gr. *στρεπτός*, twisted, and *θρίξ*, the hair.
Stroboscope. Gr. *στροβός*, whirling, and *σκοπεῖν*, to examine.

Sty. A.-S. *stigand*, an elevation. See Hordeolum.
Style. Gr. *στῦλος*, a pillar.
Subjective. Lat. *subjectivus*, pertaining to the subject.
Sublatio. Lat. *sublatio*, a removal.
Subretinal. Lat. *sub*, under, and *retina*, the retina.
Supercilium. Lat. *supercilium*, the eyebrow
Suprachoroidal. Suprachoroidea. } Lat. *supra*, above; Gr. *χόριον*, the chorion, and *εἶδος*, resemblance.
Supraorbital. Supraorbitar. } Lat. *supra*, above, and *orbita*, the orbit.
Supratrochlea. Lat. *supra*, above, and *trochlea*, a pulley.
Sursumduction. Lat. *sursum*, upward, and *ducere*, to lead.
Sursumvergens. Lat. *sursum*, upward, and *vergere*, to lead.
Symblepharon. Symblepharosis. } Gr. *σύν*, together, and *βλέφαρον*, the eyelid.
Syncanthus. Gr *σύν*, together, and *κάνθος*, the corner of the eye.
Synchysis. Gr. *σύγχυσις*, a mixing together.
Syndectomy. Gr. *σύνδεσμος*, a bond, and *ἐκτέμνειν*, to cut out.
Syndesmitis. Gr. *σύνδεσμος*, a bond, and *itis*, denoting inflammation.
Synechia. Gr. *συνέχειν*, to hold together.

T.

Tapetum. Lat. *tapete*, a carpet.
Tarsal. Lat. *tarsalis*, from Gr. *ταρσός*, a flat surface.
Tarsalgia. Gr. *ταρσός*, a flat surface, and *ἄλγος*, pain.
Tarsectomy. Gr. *ταρσός*, a flat surface, and *ἐκτοπμή*, excision.
Tarsectopia. Gr. *ταρσός*, a flat surface, and *ἔκτοπος*, out of place.
Tarsitis. Gr. *ταρσός*, a flat surface, and *itis*, denoting inflammation.
Tarso-cheiloplastic. Gr. *ταρσός*, a flat surface, *χεῖλος*, a lip, and *πλάσσειν*, to mould.
Tarsomalacia. Gr. *ταρσός*, a flat surface, and *μαλακία*, softness.
Tarsophyma. Gr. *ταρσός*, a flat surface, and *φῦμα*, a growth.
Tarsorrhaphy. Gr. *ταρσός*, a flat surface, and *ῥαφή*, a seam.
Tarsotomy. Gr. *ταρσός*, a flat surface, and *τομή*, an incision.
Tarsus. Gr. *ταρσός*, a flat surface.
Tear. A.-S. *taeher*, *taer*, *tear*, Gr. *δάκρυ*, *δάκρυον*, Lat. *lacrima*.
Teichopsia. Gr. *τεῖχος*, a wall, and *ὄψις*, vision.
Teichascopia. Gr. *τεῖχος*, a wall, and *σκοπεῖν*, to examine.
Tendo oculi. Lat. *tendo*, a tendon, and *oculus*, the eye.
Tenotomy. Gr. *τένων*, a tendon, and *τομή*, an incision.
Tension. Lat. *tensio*, from *tendere*, to stretch.
Thalamus opticus. Gr. *θάλαμος*, the inner room, and *ὀπτικός*, optic.
Thrombosis. Gr. *θρόμβωσις*, a making clotted.
Tinea tarsi. Lat. *tinea*, a gnawing worm, and Gr. *ταρσός*, a flat surface, the tarsus.
Tonometer. Gr. *τόνος*, tension, and *μέτρον*, a measure.
Trachoma. Gr. *τρᾶχωμα*, a roughness.
Trichiasis. Gr. *τριχίασις*, showing hairs.
Triplopia. Gr. *τριπλόος*, triple, and *ὄψις*, vision.

Trochlearis. Gr. *τροχιλέα*, a pulley.
Tunica vaginalis bulbi. Lat. *tunica*, a tunic, *vaginalis*, from *vagina*, a covering, and *bulbus*, a bulb.
Tutamina oculi. Lat. *tutamen*, a protection, and *oculus*, the eye.
Tylosis. Gr. *τύλος*, a callus.

U.

Umbrascopy. Lat. *umbra*, a shadow, and Gr. *σκοπεῖν*, to examine.
Unguis. Lat. *unguis*, a finger-nail.
Uvea. Lat. *uva*, a bunch of grapes.
Uveitis. Lat. *uva*, a bunch of grapes, and *itis*, denoting inflammation.

V.

Vasa vorticosa. Lat. *vas*, a vessel, and *vorticosus*, full of eddies.
Vision. Lat. *visio*, from *videre*, to see.
Visir-line. Lat. *visus*, from *videre*, to see, and *linea*, a line.
Visir-plane. Lat. *visus*, from *videre*, to see, and *planus*, a plane.
Visuometer. Lat. *visus*, vision, and Gr. *μέτρον*, a measure.
Visus. Lat. *videre*, to see.
Vitiligoidea. Lat. *vitiligo*, from *vitium*, a blemish, and Gr. *εἶδος*, resemblance.
Vitreous. Lat. *vitreus*, from *vitrum*, glass.

X.

Xanthelasma. Gr. *ξανθός*, yellow, and *ἔλασμα*, a lamina.
Xanthocyanopia. / Xanthokyanopy. Gr. *ξανθός*, yellow, *κυάνεος*, blue, and *ὄψις*, vision.
Xanthoma. Gr. *ξανθός*, yellow.
Xanthophane. Gr. *ξανθός*, yellow, and *φαίνειν*, to show.
Xanthopsia. Gr. *ξανθός*, yellow, and *ὄψις*, vision.
Xeroma. Gr. *ξηρός*, dry.
Xerophthalmia. / Xerophthalmus. Gr. *ξηρός*, dry, and *ὀφθαλμός*, the eye.
Xerosis. Gr. *ξηρός*, dry. See Xerophthalmia.

Y.

Yellow spot. See Macula lutea.

Z.

Zonula. Lat. *zonula*, dimin. from *zona*, a belt, Gr. *ζώνη*, a belt.

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